THE ENGINEER

APRIL 2, 1954

Conference on Hydraulic Mechanisms

ON Friday last, March 26th, a conference on hydraulic mechanisms was held at the Institution of Mechanical Engineers in London. In the course of this conference seven papers dealing with different applications of positive displacement oil-hydraulic machinery for power transmission were presented for discussion. The papers and their authors were as follows: "Hydraulic Deck Machinery," by Mr. J. R. Fairs; "Developments in Hydraulic Transmission Drives for Ships' Cargo Winches," by Mr. M. G. R. Petty; "Aircraft Hydraulic Pumps," by Mr. E. H. Bowers; "Hydraulics as Applied to Reciprocating Machine Tools," by Mr. G. Butler; "Hydraulic Variable-Speed Rotary Drives in Industry, with Notes on Some Interesting Applications," by Mr. F. B. Levetus; "Hydraulics in Agriculture," by Messrs. S. J. Wright and J. E. Bywater; and "Positive Displacement Machinery for Power Transmission," by Mr. T. E. Beacham. Each paper dealt in some detail with typical mechanisms in use for the particular application and provided a basis for discussion over a wide industrial field. Two or three of the authors in concluding their papers spoke of future development of hydraulics and pointed out that although this form of power transmission has long been used much research is still in progress to enlarge its field of application and increase its efficiency.

Extensions at Battersea Polytechnic

ON Friday last, H.R.H. The Princess Royal opened the extensions to the buildings of the Battersea Polytechnic, London, which have recently been completed. The extensions include a new east wing of three floors to house the metallurgy department and part of the hotel and institutional management department, a great hall block, gymnasium block and staff room block. In addition, the men's cloakrooms have been rebuilt and various rooms in the old building have been adapted to provide increased accommodation for the departments of chemistry, chemical engineering, civil and mechanical engineering and mathematics. The whole scheme, for which Mr. Owen Campbell Jones, F.R.I.B.A., was the architect and James Carmichael (Contractors), Ltd., the main contractor, has cost about £384,000. The Battersea Polytechnic goes back to 1891 in which year the foundation stone of the original building was laid by King Edward VII, who was then Prince of Wales. This building was completed and opened in February, 1894. Additions to it were completed and opened in 1904, 1910 and 1912, and the west wing of three floors was opened in December, 1929.

Institute of British Foundrymen

To mark its golden jubilee, which it celebrates this year, the Institute of British Foundrymen has published a history entitled "The First Half Century," which has been compiled by Mr. T. Makemson, who has been secretary of the Institute since 1926. When the Institute was founded in 1904, the foundry industry was growing rapidly and the output of castings in this country for engineering and building was considerable. As the history records, makers and users of castings were beginning to realise that, although founding was an art, it could also be a science, and that quality and quantity could be improved by investigating scientifically the materials which were used and the methods which were practised. The meeting at which it was decided to form the Institute—or the British Foundrymen's Association as it was originally called—was held at the Cobden Hotel, Birmingham, on April 9, 1904, and was attended by six people. Mr. Robert Buchanan became the first president and Mr. F. W. Finch, the first honorary secretary, and by the time the newly-formed Association held its first convention in August, 1904, there was a membership of eighty-nine, a figure which had increased to 100 by the end of the year. To-day, the membership stands at 5300. A petition was lodged for incorporation by Royal Charter early in 1921, by which time the name had been changed to the Institution of British Foundrymen, and the intention was that the application for incorporation should be made under that title. But, the history notes, by some unexplained error the word "Institute" was used and the Charter was naturally granted to the Institute of British Foundrymen. Mr. Makemson has faithfully recorded the development of the work of the Institute during its first fifty years, mentioning in particular the contribution which it has made, and continues to make, to technical progress in the foundry industry, its work in the field of education and technical training, and the many international activities which it has initiated and encouraged.

Research in the Coal Industry

THE annual general meeting of the British Coal Utilisation Research Association was held in London last Monday and, in the course of his presidential address, Sir Charles Ellis, F.R.S., scientific member of the National Coal Board, described some of the experimental work done by the Association during the past year. He said that the Association's new domestic appliance laboratories had shown their value and new factors in design had indicated the possibility of reducing smoke in domestic appliances. The use of small-bore pipes with forced circulation for small scale central heating was a promising development and a gratifying development in steam-raising was the installation in industry of small chain grate conveyors in shell boilers. This and similar developments with central and semi-industrial heating were of national importance in that they facilitated the successful and smokeless burning of low grade fuels. Referring to gas producers, Sir Charles said that the main work of the year had been a study of producer tars to reduce blockage in the distribution mains, in which work considerable success had been achieved. Fundamental studies of coal had hitherto been concerned mainly with its chemical constitution, but an enormous saving of empirical work would result from a reasonable knowledge of the structure and constitution of coal and the Association was devoting considerable effort to this subject. One main line of attack was the investigation of the solvent extracts of coal which had been shown to reflect the structure fairly faithfully. A quite different fundamental investigation aimed at studying the mechanical properties of coal such as the elastic constants, fatigue, permanent and actual breakage. Sir Charles also said that it was not so generally appreciated that one of the Association's functions was the transfer of staff trained within its walls to outside appointments. That, he claimed, was one means of expediting the passage of scientific method to industry.

Smoke Reduction in the City of London

A CONFERENCE to consider the subject of smoke reduction in the City of London was held at the Mansion House last Friday. It was organised jointly by the Coal Utilisation Council and the Combustion Engineering Association. The Lord Mayor of London, Sir Noel Bowater, said, in a welcome to the delegates, that he was sure that anything which could be done to make the City of London a smokeless zone would have the "wholehearted support of the citizens of the square mile." The opening address at the conference was given by Captain (E) W. Gregson, R.N.R., M.I.Mech.E., chairman of the advisory committee on fuel efficiency, who spoke of the dirt and deterioration and the dangers to health caused by smoke. He went on to say that smoke was an outward and visible sign of bad combustion and therefore of fuel wastage, which simply could not be afforded. The time was ripe for action as distinct from exhortation, Captain Gregson remarked, and he felt that it was a matter for satisfaction that the remedies were known. The papers presented for discussion at the morning session of the conference were by Sir John Charrington, who dealt with "The Available Fuel," and by Mr. W. C. Moss, whose subject was "Smoke Reduction in Small and Domestic Appliances." At the afternoon session, papers on "Central Heating," dealing in particular with sectional boilers and shell and water-tube boilers, were presented by Mr. W. H. Gamble and Mr. J. R. Kell.

Research on Reclamation from the Wash

WE are informed by the Department of Scientific and Industrial Research that research into the possibility of reclaiming more land from the Wash has been started by the Hydraulics Research Station. As far as can be seen at the moment, it is stated, it might be possible eventually to make 50,000 acres of valuable land available for reclamation. The problems of drainage and reclamation in this area are well known; the sea level relative to the land is rising; the peaty soil shrinks as it is dried out (in some places a lowering of 11ft in eighty years has been experienced), and there is danger of flooding from the river channels passing, between embankments, through the fen. A typical example of the civil engineering problems of the area was described recently in THE ENGINEER of February 12th and 19th last, in the article entitled "Flood Control Works on the River Welland." Most of the research work carried out up to now by the Hydraulics Research Station has been an analysis of past changes in the sea approaches to the Wash, the central part of it, and the reclaimed areas along its margin. The work is not yet far enough advanced for any comprehensive scheme of improvement to be suggested, but it is pointed out that the chief problem is to find a design for training works which will accelerate accretion and improve drainage at the same time; such a solution might be possible, it is thought, by treating the Wash as a single unit, instead of considering each river estuary separately, as has been done up to the present.

Freight Charges and Transport Efficiency

THE annual luncheon of the Mansion House Association on Transport was held in London on Friday last, and was attended by Sir Brian Robertson, chairman of the British Transport Commission. In the course of a speech, Sir Brian made reference to increased freight charges on account of the British Transport Commission's increased costs, and said that the Commission was making a very determined drive on productivity and economy. He went on to say that he was quite convinced that the Commission could economise substantially without detriment to efficiency, and that it could be done without any drastic policy of staff dismissals. Sir Brian then commented on the new freight charges scheme which, he said, would be submitted for approval within a few months, and which would, in fact, represent a scale of maximum charges. It had been decided that public transport should work in a competitive climate and the Commission must therefore act accordingly. Although it was not the purpose of the new freight charges scheme to reduce the Commission's overall revenue, it would remove, Sir Brian claimed, many anachronisms and anomalies.

Recording Signals from Resistance Strain Gauges

By D. A. SENIOR, M.A., A.M.I.E.E.*

(*Concluded from page 449, March 26th*)

No. III.—A TWELVE-CHANNEL DIRECT STRAIN RECORDER

The instrument consists of a recorder, a control unit and a power unit. The recorder is an Admiralty Research Laboratory Recorder, Type A,† which employs twelve moving coil galvanometer elements. These are designed for direct connection to the strain gauge bridge so that no amplifiers are required. The control unit carries ratio arms for twelve strain gauge bridges and supplies power at suitable voltages for the motor and lamp in the recorder. It also provides facilities to balance the bridges and to ensure that the galvanometers operate under optimum conditions of damping. Power is taken either from the power unit or from 24V batteries. The power unit runs from 230V, 50 c/s mains and supplies stabilised d.c. and raw a.c. to the control unit. Strains are recorded with an accuracy of ±0·1 ton per square inch (in steel) for static and ±0·25 ton per square inch for dynamic strains up to a frequency of 55 c/s. Special strain gauges running at 3W are employed with the present instrument, though provision is made for lower powers to be used if lower strain sensitivity can be accepted. Developments in hand aim to achieve the same performance with strain gauge power dissipations possibly as low as 0·5W.

THE instrument described in this article employs twelve galvanometers, each covering a frequency range extending from zero to 55 c/s. It is a prototype built in order to explore the practical limits of the technique. There are three components and the weight, dimensions and cost based on production of a batch of six instruments are :—

Component	Weight, lb	Dimensions	Cost, £
Control unit	51	30in × 16in × 5in	310
Power unit	96	27in × 13½in × 15in ...	90
12-channel recorder...	15	22in × 4½in × 5½in	500
Complete instrument	166	4·8 cubic feet	900

The weight, dimensions and cost of the control and power units will be considerably reduced if developments which are discussed later are successful. Even in its present form, however, the instrument compares favourably with other methods of strain recording which use amplifiers. Electronic amplification has the advantage that lower values of strain can be recorded and that photographic recording can be avoided by the use of pen recorders.† Alternatively, higher frequencies can be recorded if the cathode ray oscilloscope is used. On the other hand, for the same accuracy, the cost appears to be up to three times that of the direct recording instrument, whilst volume and weight are up to five times as great. Within its sensitivity and frequency range the direct recording method seems to the writer to have no competitor for accuracy at the price, and no competitor at any price in its robustness and simplicity.

THE INSTRUMENT

The control unit is shown in Fig. 14 and the whole instrument packed for transport in Fig. 15. The basic circuit is shown in Fig. 16. In operation, stabilised direct current is applied to twelve Wheatstone bridges, one or more arms in each bridge consisting of an active strain gauge attached to the structure under test. The out-of-balance currents in the bridges are fed to twelve specially designed moving-coil galvanometers contained in an Admiralty Research Laboratory Recorder, Type A. They give a photographic record of the time variation of the strains being investigated. The instrument will now be described in greater detail.

THE POWER UNIT

A 200W, 50V Westinghouse "Noregg" stabilised power supply is built in to the power unit along with smoothing condensers. This equipment operates on a 230V, 50 c/s supply and reduces a mains voltage fluctuation of 10 per cent to one of 1 per cent in output voltage. No provision is made for variation in mains frequency, on the grounds that voltages are liable to change rapidly due to local disturbances, but frequency changes are comparatively slow, since they are governed by the inertia of the rotating parts of all the generating machinery of the grid. A rheostat and voltmeter are therefore provided so that voltage fluctuations from this cause may be corrected manually. Provision is made for battery operation when no mains are available. A battery voltage of 24V is catered for, since this can conveniently be supplied by two 12V accumulators. Higher voltages would make the equipment unduly heavy and a sacrifice in sensitivity would probably be preferred.

THE CONTROL UNIT

The direct current is taken through a control switch and the rheostat already mentioned to twelve ratio arm units which are mounted six on each side of the central panel in the control unit (Fig. 14). A cooling fan is mounted in the centre of the unit. Air is drawn in through the grid and escapes between the panels of the ratio arm units, which are mounted slightly proud of the casing. Power for the motor and lamp in the recorder is provided by a transformer and two rectifier circuits in the control unit. In battery working, motor and lamp currents are taken from the battery via appropriate dropping resistances, switching being arranged so that the full lamp current is taken only when the recorder motor is running.

Connection from the power unit to the control unit and from the control unit to the recorder is made by means of screened cables and Breeze plugs and sockets. The recorder is plugged in to one socket for mains working and a second socket for battery working. By the use of internal connections within the plug it is made impossible to damage the control circuits, overload the motor or lamp, or interconnect mains and battery by any failure to observe instructions.

THE RATIO ARM UNITS

Each unit contains a pair of 200-ohm strain gauges, which act as ratio arms in one strain gauge bridge. The bridge is completed by means of the active and compensating (or dummy) strain gauges which are mounted on the structure under test and wired to the terminals on the panel of the ratio arm unit. Provision is made for reducing the voltage on any individual strain gauge bridge in cases where lower sensitivity is desirable. Dropping resistances of 200 ohms and 400 ohms are arranged in series with the current supply of the bridge and may be short circuited by means of a selector switch. This reduces the bridge volts to one-half or one-quarter of the input volts.

Details of the construction of the ratio arm units are given in Fig. 17. The ratio arms consist of two composite strain gauges mounted one on each side of a 4½in by 1¼in

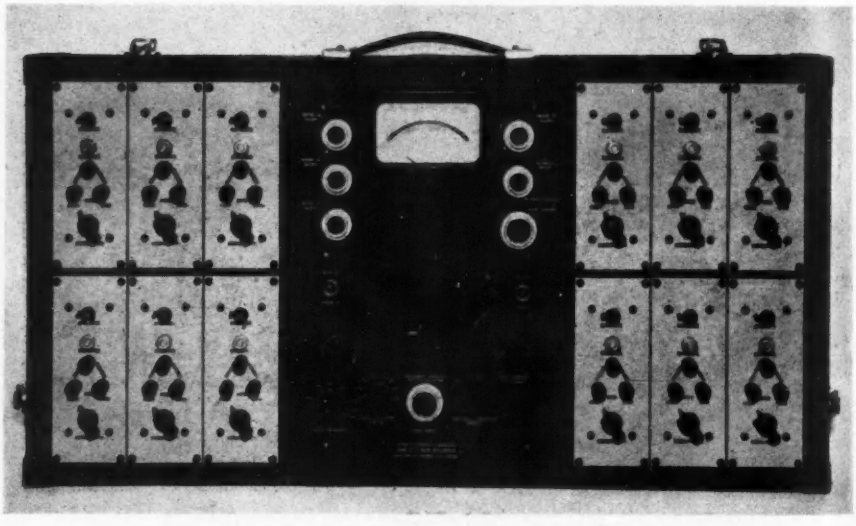


Fig. 14—The Control Unit of the Twelve-Channel Direct Strain Recorder

* Admiralty Research Laboratory, Teddington.

† The disadvantage of photographic recording—the time factor—is largely overcome by the use of rapid processing methods. A machine based on the Kodak hot drum principle has recently been developed at the Admiralty Research Laboratory. Dry records on paper are produced at a speed of 1in per second. The record may be examined within eight seconds of recording and handled 20 seconds later. The machine will be demonstrated in conjunction with the direct strain recorder at the forthcoming Physical Society Exhibition (April 8th–13th).

Duralumin cantilever. The composite gauges each consist of four 800 ohm gauges mounted in parallel on the same paper, and are bonded to the cantilever with Bakelite cement. The cantilever may be deflected by means of the screw labelled " Balance " (*E* Fig. 17) ; this operates through oil seal bellows and a ball which bears against the cantilever near the tip. A precompressed spring and end stops

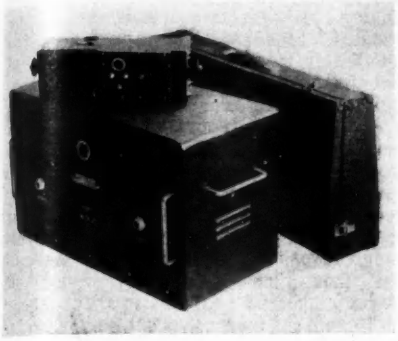


Fig. 15—The Direct Strain Recorder Packed for Transport

ensure that the cantilever may be deflected to the elastic limit in both directions but no further. A maximum difference of ±0·9 ohm between gauge and dummy can be balanced out. The cantilever and the 200 ohm and 400 ohm dropping resistances are contained within a Duralumin casting, which is closed by an oiltight lid. The container is filled to 1in of the top with transformer oil to ensure even cooling of the ratio arms and minimise zero drift in the bridge.

Damping Adjustment

Optimum frequency response in each galvanometer is ensured by arranging that

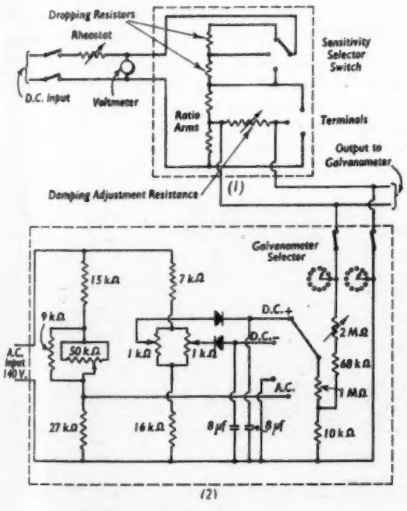
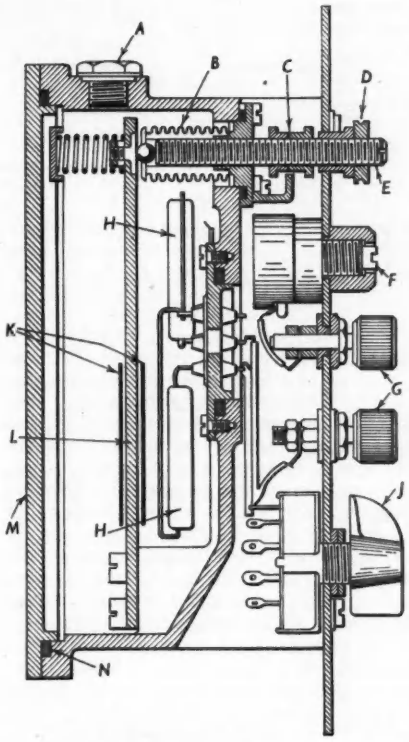


Fig. 16—Basic Circuit

the motion of its coil is subjected to 0·6 of the critical damping. To achieve this, the resistance across the terminals of each galvanometer is adjusted to match the galvanometer by means of a 5000 ohm variable resistance which is included in the ratio arm unit. This resistance is connected across the galvanometer leads, i.e. between the junction of the ratio arms and that of the gauge and dummy, and is adjusted to such a value that the resistance presented to the galvanometer comprising (*a*) one ratio arm the active gauge and leads, (*b*) the other ratio arm, the dummy gauge and leads, and (*c*) the adjusting resistance, all in parallel, constitutes 0·6 of critical damping.

The damping adjustment is carried out by means of the circuit shown in the dotted enclosure numbered 2 in Fig. 16. This circuit provides an alternating voltage at mains frequency and two direct voltages which are equal and opposite. The alternating voltage is arranged by means of a potentiometer to be such that, taking account of the frequency response of a correctly damped galvanometer, the peak-to-peak deflection on alternating current is equal to the difference between the d.c. deflections. The magnitude of the required alternating voltage is a function of the natural frequency of the galvanometer, and of the mains frequency which it is sufficiently accurate to assume constant. The potentiometer which governs the alternating voltage presented to the galvanometer on test is therefore calibrated



A—Oil filler.
B—Bellows.
C—End stops.
D—Indicator.
E—Balance adjustment.
F—Damping adjustment potentiometer.
G—Terminals.
H—Dropping resistors.
J—Sensitivity selector switch.
K—Ratio arm strain gauges.
L—Cantilever.
M—Lid.
N—Oil seal.

Fig. 17—Ratio Arm Unit

in cycles per second referring to the natural frequency of the galvanometer. A selector switch is provided so that each galvanometer may be tested in turn. Switching is arranged so that the supply of direct current is broken whilst damping adjustment is carried out.

Performance

With the present galvanometer elements, strains equivalent to 5 tons per square inch in steel give a deflection of 1 cm on the film. Static strains are recorded with an accuracy of ±0·1 ton per square inch, whilst strains at frequencies up to 55 c/s are recorded with an accuracy of ±0·25 ton per square inch.

Future Developments

The present instrument is designed to work with strain gauges capable of dissipating 3W if the maximum accuracy of recording is to be attained (±0·1 ton per square inch for static and ±0·25 ton per square inch for dynamic stresses in steel up to 55 c/s). This means in practice that either the special composite gauge manufactured by British Thermostat or the printed strain gauge of Saunders Roe/Technograph must be used. The composite gauges occupy 1½ square inches, and although the same dissipation can be achieved with a smaller printed gauge there still remains the problem that the structure must be able to dissipate a considerable amount of heat which is generated within the gauge. Moreover, in multi-channel working the requirement for d.c. power becomes a difficult one to meet. For twelve-channel working, as at present, about 150W at a stable voltage of 50V must be supplied. On mains working this involves a power unit weighing 96 lb. With accumulators the weight would be even greater. Reduction of heat dissipation, cost and weight can be obtained by reducing the working voltage to one-half or one-quarter, but only at the expense of a corresponding loss of accuracy. An alternative is to accept a lower frequency range, but this leads to a fragile galvanometer, which would be difficult and costly to make.

The answer to the problem lies in the improvement of galvanometer design. It has been shown theoretically in No. I of this article that a galvanometer embodying a coil held rigid by varnish alone without the use of bobbins would cover a similar frequency range with the same recording accuracy, but with a power dissipation in each strain gauge possibly as low as 0·5W. Not only would this make the technique more flexible (smaller gauges could be used on smaller sections of metal), but the instrument would be considerably lighter and cheaper to manufacture. As soon as production of these " bobbinless " coils is assured it is intended to design a smaller, lighter, cheaper, and more generally useful instrument to cover the same frequency range with the same accuracy.

Acknowledgments

The writer wishes to express his appreciation to Mr. Gatenby, who carried out the tests which led to the design of the ratio arm units ; to Mr. Elliot, who made the first one ; to Mr. Thurlow, who designed the production model ; and to Mr. Bouffler and Mr. Strong, who calibrated the damping adjustment circuit and made final adjustments.

The writer is particularly indebted to Mr. Margary, who developed the A.R.L. recorder. His suggestion that this recorder might facilitate the direct recording of strain gauge signals led to the work which has been described.

The ratio arm units were made by Arthur Hill and Son, Ltd., Kingston. The carrying case for the control unit was designed by Geometric Designs, Ltd., of Victoria Street, London, and made by Waights, Ltd., Sydenham. The control unit and power unit were wired by Winston Electronics, Ltd., of Hampton Hill.

Acknowledgment is made to the Admiralty for permission to publish this article.

Self-Unloading Vehicles.—In our issue of November 6, 1953, page 603, we illustrated and described a self-unloading road vehicle, which had been developed by Charrold, Ltd., 40, Trinity Square, London, E.C.3, for delivering coal in bulk. We are now informed by the company that it has now produced a vehicle of similar design which can be used for the bulk delivery of other products, such as grains, powders and other free-flowing materials. The bodies of these vehicles consist essentially of enclosed containers with belt conveyor floors, which deliver material out of the rear on to a second belt conveyor carried on a swinging boom. The boom can be swung through an arc of 180 deg. and its end elevated or lowered to heap the material being delivered, and it can be introduced through a relatively small hatch or manhole to deliver straight into a building.

French Locomotive Experiences

By EDWARD H. LIVESAY

(*Continued from page 452, March 26th*)

No. IV—EXPRESS TRAINS RUNNING BETWEEN PARIS AND ARGENTAN; 2-8-2 TYPE LOCOMOTIVES

EXPRESS trains weighing 600 tons or more do not run regularly in Britain; if they did, they would be worked by 4-6-2 or 4-6-0 locomotives, or possibly 2-6-2, very likely double-headed if stops were frequent, and time were kept. No eight-coupled engines capable of doing this sort of work exist in Britain to my knowledge, nor have they since the conversion of the 2-8-2 Gresley "Cock o' the North" class into "Pacifics." In France things are different, eight-coupled engines of various types having been built in large numbers for many years to handle both express and fast freight trains. This article describes some of the work done by 2-8-2 mixed-traffic engines with fairly fast trains running between Paris and Argentan, the first part of the direct route to Granville, and indirect to Caen, Cherbourg, St. Malo and Brest, bringing out the chief features of these fine engines. The runs were made with train No. 405 from the Gare Montparnasse, in Paris to Argentan, returning with train No. 406; the former weighed about 560 tons gross, and the latter 630 tons, both being termed "express," and accommodating first, second and third-class passengers. Between Paris and Dreux, which is roughly halfway to Argentan, the trains only make one stop, at Versailles; between Dreux and Argentan there are three. The speed throughout is limited to 68 m.p.h. for locomotive reasons—the small size of the driving wheels, 5ft 4¾in; it was reached with ease, under all conditions of gradient or the absence of it, and was never exceeded. "Few trains and heavy" is the French policy, as opposed to the British ideal of "many trains and light," though with me, and the engines treating everything with such cheerful contempt. It was only later, when studying the profile, that I saw what they had been up against, and it is a pity that a fully detailed profile is not possible for reproduction. For such services powerful engines are essential, capable of rapid acceleration, and this is exemplified by the machines dealt with in this article, Nos. 141-P232 and P236, the chief particulars and dimensions of which follow; they are illustrated by Figs. 23 and 24.

Driving wheels, diameter	5ft. 4¾in
Cylinders, h.p.	16½in. by 28in
Cylinders, l.p.	25½in by 28in
Heating surface:	
Firebox	156 sq ft
Tubes	2010 sq ft
Superheater	939 sq ft
Total	3105 sq ft
Length of tubes	19ft 9in
Number of tubes, large	30
Number of tubes, small	125
Superheater elements, Houlet	26
Superheater elements, Schmidt	4
Grate area	46·24 sq ft
Steam pressure	294 lb

Walschaerts valve gear, non-independent; piston valves; one injector; one A.C.F.I. pump and feed water heater; mechanical stoker; weights as per diagram.

The Gare Montparnasse is deceptive to a stranger and would-be passenger, particularly if he and French are not on speaking terms. There are really two stations, connected, but a considerable distance apart, and it is hardly necessary to say that this stranger instinctively made his way to the wrong one, with very little time to spare for locating train No. 405, which he only found after exasperating, though amusing—in retrospect—struggles with the language and station staff, neither of which he understood, both seeming only to make his confusion worse confounded. However, ultimately the darkness was dissipated and light appeared; I arrived alongside the engine and was greeted by sundry officials, one of them being Monsieur Boit, who was to act as interpreter during the runs. The fact that he was chief of the Caen roundhouse and had come 150 miles from that city on my account, was typical of the many examples of care and courtesy shown by the S.N.C.F. on my behalf, for which I cannot be too grateful. Speaking excellent English and looking very English, too—I do not expect he will necessarily regard this as a compliment, though I hope so—he said he had recently spent some time at Derby under the "exchange" arrangement, by which French and British railwaymen engaged in shop work changed partners, crossing the Channel, it was hoped, to their mutual advantage—more on this subject later. Inspecteur Gillardin also rode in the cab, making five occupants in all, Mecanicien Menard and Chauffeur Legour being the other two. The engine was No. 141-P236, 2-8-2, four-cylinder compound, of a class first built in 1942, 200 of which are now running. It was mechanically stoked by modified "Standard" HT1 apparatus; the superheater temperature gauge was out of commission, strange to say—seldom anything is defective on a French engine, in my experience—and, of course, a Flaman recorder was in position; I will spare the reader my usual comment. Seats were provided for the crew, but I declined an invitation to occupy the fireman's, knowing that if I accepted it he would be inconvenienced, all his controls being conveniently arranged on the assumption that their manipulator would be seated. Screened coal was in the bunker; this is preferred for mechanical stoking, and it has been found that less is burned than of the usual lumpy, dusty kind.

Train 405 moved away punctually at 3.40 p.m., the engine showing no trace of slipping; h.p. steam was, of course, admitted to all four cylinders at the start and the working changed to compound when the cut-off was shortened. Acceleration was very good, notwithstanding the heavy gradient, 1 in 100, that begins immediately outside the station, the engine picking up speed rapidly, and we passed through Sevres, 6 miles, in under 10 min, and Viroflay, 8·5 miles, in less than 10 min. A burrowing junction succeeded—very common round Paris, I noticed—and the brakes went on for the Versailles-Chantiers stop, made at 3.56; 10·4 miles in 16 min start to stop, good work with 560 tons over a heavy gradient. Restarting at 3.59, again without slipping—French locomotives very seldom do slip, a mystery I have not yet fathomed—we had scarcely got nicely going when my attention left the cab,

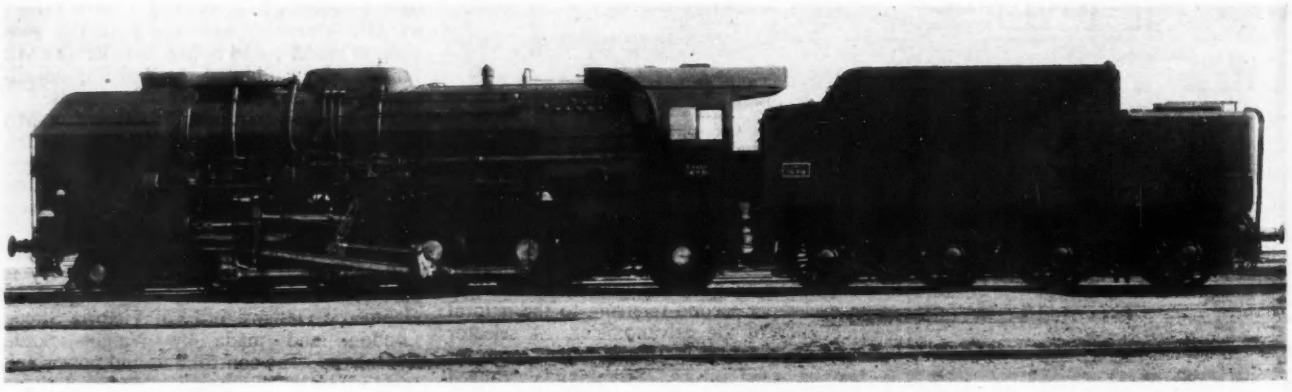


Fig. 23—Four-Cylinder Compound Mixed-traffic 2-8-2 Locomotive

admittedly this comparison should not be run into the ground. The route between Paris and Argentan is quite the heaviest over which I rode in France; probably it was chosen by the S.N.C.F. for this very reason, and this explains why 2-8-2 engines are used on it. The condensed profile (Fig. 25), though indicative enough, does not really bring out its severity, four-fifths of it consisting of gradients up and down with long stretches of 1 in 100, and many shorter lengths equally heavy, level track being chiefly conspicuous by its absence. I did not realise this at the time, not having a profile irresistibly attracted by a vision of the sunlit Palace of Versailles to the right, set like a gleaming white jewel on green velvet, amid shimmering lakes and flashing fountains. An unforgettable sight, so fascinating that for a few moments I ceased to respond to the rival attractions of Engine No. 141-P236. "Mon Dieu! Versailles and a locomotive—he mentions them in the same breath!" Ah! but the æsthete forgets—this was a French locomotive! I can rhapsodise over Versailles and a locomotive, too, when the latter is running as perfectly as this one.

It was a glorious day, born for enjoyment,

all the more appreciated as P236 was in beautiful shape, working like a sewing machine and riding like a well-designed locomotive can ride, but very seldom does—outside France! Like "V2," No. 4793 did between Dundee and Aberdeen in 1939—that was an unforgettable engine, the action of which has never been bettered in my experience; I described it in THE ENGINEER at the time. Everything about P236 was behaving as it should; not a knock, rattle or leak sounded anywhere, and I asked myself, as I did on subsequent occasions

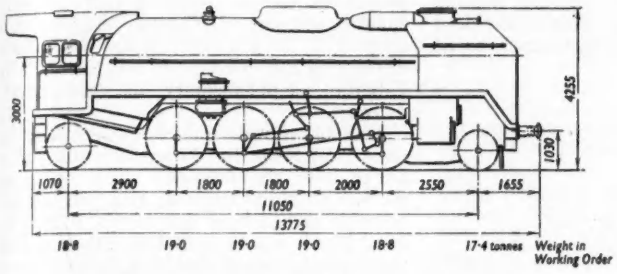


Fig. 24—Leading Dimensions and Weights of Four-Cylinder Compound Mixed-traffic Locomotive

until I was reassured, whether the engine on which I happened to be riding was just a "run-of-the-mill" machine, or one specially tuned for the occasion. Always the former, I was told, and I am convinced it was so, as the hundreds of other engines I saw at work all seemed to be in good condition, too. I never once heard in France what one so often does elsewhere—locomotives with clanking side-rods, wheezing spindles, uneven exhausts. This particular class of engine, I was told, is always handled by the same crew, a very good system, of course, but this alone does not account for the exceptional mechanical condition of the machine, which is more a matter of shop credit.

Dial indicators are far more comprehensive in French than in British cabs; in this one there was a vertical tube measuring the smokebox vacuum by the rise and fall of a column of water, but nothing appears in my notebook of its readings—*mea culpa*. The fireman's selection included one combining three needles, indicating (1) jet pressure, (2) stoker engine, (3) boiler pressure. The A.C.F.I. lubricator was placed over the fire-door, under the eye of the fireman at all times, and was steam operated; it, too, had appropriate gauges, of course.

The signal system was of the usual audible type energised by a ramp between the rails. A horn sounds when passing distant signals, one note for "off," two for "on," which must be acknowledged by the driver, not to prevent automatic brake application, but because a corresponding entry is made on the Flaman recorder; if it does not appear thereon the driver listens to another sort of music later.

West of St. Cyr, at the summit of the heavy 12-mile climb from the Gare Montparnasse, finally clear of suburban Paris, we began running past great level fields of stook and stubble basking under the summer sun, almost inducing nostalgia for the Canadian prairie—*almost*, be it acknowledged. This was a country either flat or gently rolling, of large farms and great distances, through which stretched the roads, straight and unfenced, apparently with little traffic on them by English standards. The 68 m.p.h. limit had soon been approached after leaving Versailles, the train keeping very close to 60 m.p.h. plus or minus, but there was little or no dust in the cab, thanks to rock ballast, mechanical stoker and front-end "blinkers," which carried what little smoke there was well above the roof. As for steam, this was too thoroughly superheated, both before and after use, to show at all this shimmering summer day. Two water gauges were noticed, as against the one usual in N. America, and the two sets of valve gear were controlled by one wheel irrespective of what kind of working was being indulged in—h.p., compound, equal or differing rate of expansion, a combining and locking gear making this possible. The h.p. steam admitted to the l.p. cylinders at starting is governed by a subsidiary regulator hung coaxially with the main one, this being apparently standard practice on French locomotives.

The riding at speed was exceedingly good, far better than I had conceived possible with a locomotive of this type. Here was a complicated four-cylinder engine, of a design one would more readily associate with freight work than fast passenger, with small eight-coupled wheels revolving at high speed; a machine of a complexity unknown in Britain, yet the working of the whole mechanism from end to end was completely unobtrusive. Not a fault was to be heard or felt anywhere, the engine rushed that heavy train along up hill, down dale and on the level without any sign of stress or strain; from any evidence of effort it might almost have been drifting! Really, there is little exaggeration about this panegyric—it is close to being a true bill. Balancing was evidently as good as theory and practice, together, could achieve. I could feel nothing of the rapidly moving rods either inside or outside the frames; they all worked smoothly and sweetly. The equalised suspension also was in perfect condition, giving that curiously light, springy motion that I was to find typical of French locomotives, a feeling quite different from that as a rule experienced elsewhere, one in which there is little or no impression of wheels running on rails. I could not help wondering if this was exceptional—this, by the way, was only the second run made in the cab over French metals—or whether it was characteristic of Gallic locomotives. Were they all going to behave in this charming manner; was it really so good as I imagined, or is the novelty of everything affecting my judgment, and making me look at things through rose-coloured goggles? Further experience was to prove, however, that this charming behaviour was characteristic; that novelty had nothing to do with the good impressions recorded; they were confirmed by every run.

Nearing Montfort, 27 miles from Paris, there was a lengthy restriction to 20 m.p.h. for relaying; temporary signals are erected at such places, while the work is in progress. This was a Saturday afternoon, yet farmers and trackmen were working as usual; the fact that farmers were doing so did not surprise me—they work a seven-day week anyway, especially at harvest time, and an eighteen—not an eight—hour day at that. It was strange to see trackmen at work, though, when British runs made on the same day of the week had revealed a deserted right-of-way, such as that between Edinburgh and London. Much French track is unfenced and in the absence of cowcatchers straying stock must be rather a hazard, but possibly French cows are more watchful than British and stop, look and listen. Failing this, and quoting Stephenson, "It would be bad for the coo" if they did not.

West of Montfort my notebook has an entry: "Length of apparently cement-based track—inquire about this," but having forgotten to do so, the statement need not be accepted. The frame hung in front of the driver containing the working timetable, special notices, restrictions, &c., again received favourable comment; it was observed for the first time on the "Golden Arrow" run, and was subsequently found to be universal practice. Certainly an idea worth copying. The Flaman recorder is also a *sine qua non* in France; its continuous memorandum enables a comparison to be made with the working timetable, and shows beyond a peradventure how closely the driver has followed instructions. The Flaman recorder is considered so indispensable in France that no engine is allowed to leave the shed unless the instrument is in working order; moreover, drivers do not like to run with it even temporarily out of action, as it protects them against possibly unjustified charges which otherwise they might not be able to refute.

The Dreux stop was made at 4.49, 2 min late, for which everyone was apologetic, but I assured all concerned that it was of no importance—"no matter—more was lost on Mohacz field!" In Britain one is used to far worse unpunctuality than that, and I mentioned that in Canada I had once been in a train running later and later, until on becoming twenty-four hours adrift it went out of existence altogether, reappearing in next day's schedule

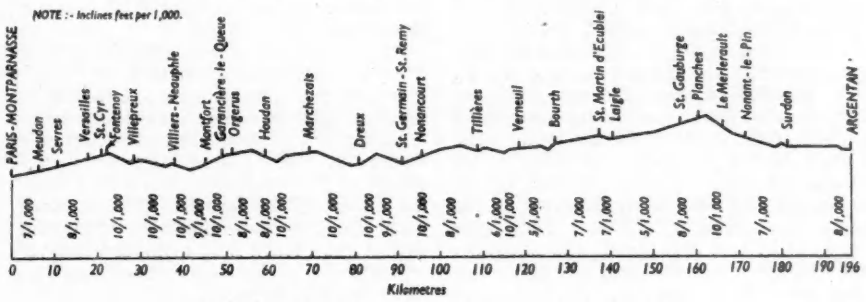


Fig. 25—Profile Between Paris (Montparnasse) and Argentan

O.T.; this consoled my French friends. The 38·7 miles from Versailles to Dreux had been covered in 50 min, at an average of 46·4 m.p.h. The lengthy restriction to 20 m.p.h. and the permitted maximum of 68 m.p.h. should be borne in mind; in any case, the schedule called for nothing higher; the running speed had seldom fallen much below 60 m.p.h. The whole stretch from Paris had made heavy calls on the engine, and the average speed is much more creditable than it at first appears. Equally severe conditions were to succeed Dreux, and would continue all the way to Planches, 48 miles. The Dreux

stop was short, 4 min, but 2 min longer than the working timetable allowed. We left at 4.55, 6 min late, and the train took up the running over the best stretch of track I had noticed since leaving Paris, with new sleepers and rock ballast. Most of this line had been relaid since the war, during which it had been badly damaged. It will be recalled that the Argentan district was very much in the invasion area. The speed quickly rose into the 60s, the stoker doing very good work, keeping the fire even and smokeless, and the pressure well up ; the cab remained clean and dustless. The country was very open hereabouts, Manitoba-like, only more attractive—neater, and more " finished," with wheat, wheat everywhere, almost as far as the eye could see, yet the inclination both of track and country tended always upward to Planches.

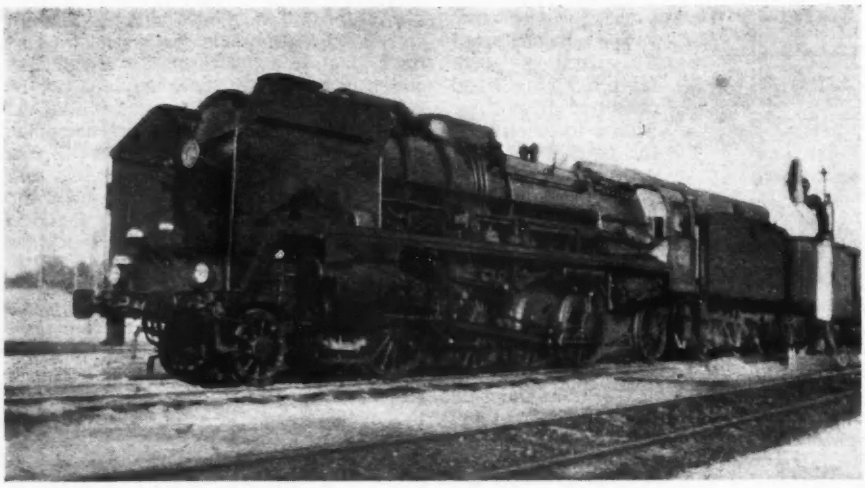


Fig. 26—No. 141—P232 at Argentan

A stop at Verneuil-sur-Avre, 5.44, only 2 min late now, so 4 min had been recovered in the 21·6 miles from Dreux, making the average 48·8 m.p.h. This Dreux-Argentan section would be somewhat more demanding than the run from Paris had been, with three stops as against one, and time-keeping would be correspondingly harder. No. P236's rocking grate was given a shake, and the conveyor speeded up a little ; shortly after came Laigle, and a stop, at 5.40, and water was taken on ; the restart was made at 5.44, still 2 min behind time. No time is wasted in stations on this run, evidently—everything is done at the double. Here I took to the train until the next stop, at Surdon, for various reasons, one of which was to see if the coaches were as satisfactory as the engine ; I found they were. They were roomy and clean, rode quietly and smoothly, and the corridors were not cluttered with baggage in the exasperating British fashion ; possibly this is not allowed in France, or maybe a *lex non scripta* is equally effective. A pity there isn't such a thing in Britain ! At Surdon, 6.14, 1 min late, I rejoined the engine, with barely enough time to do so, only 1 min being allowed by the timetable, and was unable to retrieve my camera from the enginemen's locker, rather inconveniently located at the back of the tender. I must say the comfort and convenience of the crew do not seem to be considered very much in France, or, in one respect, the safety of an observer ! Look at Fig. 23 ; it will be seen that the door is apparently not much more than knee-high, and a tall man such as myself might easily lose his balance and capsize over it. However, losing one's balance is not very likely on a French engine, they ride so well ! Nevertheless, if I dare suggest an improvement to P236 class engines, the doors should be 18in deeper, thus removing the only fault I could find in the entire machine. Inside the cab, over the driver's window, was a notice : " Attention aux catenaires—Danger de Mort," adorned with a zig-zag warning of overhead conductors, and another, " Attention gabarit," to beware of the loading gauge—keep your head in, that is to say. There should be one beside the doors—keep your whole body in. But so far as the controls are concerned, nothing had been overlooked ; the Flaman is placed right beside or in front of the driver, so he cannot help consulting it ; it is not stowed away under the fireman's seat, as it used to be on the Gresley " A 4s," where after dark it couldn't be seen at all.

Argentan was reached at 6.26, dead on time, after a fast 8·7 miles from Surdon, start to stop, the easiest stretch since leaving Paris, mostly level, beginning, as the profile shows, at Planches, covered in 11 min, 47·5 m.p.h. start to stop. The 117·6 miles from Paris, inclusive of five stops totalling 14 min, had been made in 2 h 46 min, 42·5 m.p.h., running average 46·5 m.p.h.

Argentan is an important junction, branches going off north and south to Caen and Le Mans, the main line going on to Granville, on the Atlantic coast. The hour available before returning to Paris was pleasantly filled in by dinner at the station restaurant with Messieurs Boit and Gillardin, during which the matter of the former's work at Derby came up, his impressions of contrasting British and French shop methods being very interesting. To him there seemed too few tools in British sheds, which resulted in engines having to wait their turn, often going to the shops for repairs which in France would be carried out on the spot. This may be one explanation of the poor condition of many of the engines on which I have ridden in England, so very different from the generality in France. I suggested to him that, judging from what I had seen in France so far, British railways had little to teach his compatriots—the shoe was on the other foot. My notebook contains no record of his reply ; being French, and polite—the two things are synonymous in my experience—he was probably too considerate of my feelings to be outspoken on the subject. He need not have been. I know my opinion, at any rate !

Train No. 406, with which we were to return to Paris, arrived from Granville considerably behind time, due to imperfect connecting arrangements with the train from Brest and St. Malo ; not only was this Saturday, when trains are apt to be overcrowded, but it was the holiday season as well. The engine was No. 141-P232 (Fig. 26), 2–8–2, of the same class as before, but the load was heavier, at least 630 tons gross. With Messieurs Boit and Gillardin in the cab again, and Mecanicien Le Boucher and Chauffeur Bouvier in control, we left at 7.27 p.m., 17 min late ; the weather was as perfect as on the outward run, a lovely summer evening. Of course, there was no slipping at the getaway ; steam was a little down, and a few scoops of coal were fed by Gillardin, supplementary to the stoker's delivery.

The blowdown was opened, which is done every 50km for 30 sec, according to a notice over the fire-door. The riding at 60 m.p.h., soon attained, was just as impeccable as had been that of No. P236 ; so good that it was actually better than that of the tender, which is decidedly unusual—it is generally the other way about.

The Surdon stop was made at 7.37, 10 min late ; 9 miles in 10 min with the restart at 7.39. I noticed how soft the exhaust was, though h.p. steam was, of course, being used in all the cylinders—soft, but full, very pleasant to listen to, thanks to the Kylchap double blast pipe (Fig. 27), with which it is impossible to tear the fire to pieces on any regulator opening. The steam, down at Argentan, was right up again now, and when climbing the long rise to Planches, taking the culminating 2½-mile 1 in 100 pitch at 60 m.p.h., the superheat was noted as 370 deg. Cent. (794 deg. Fah.), the highest I have ever come across on a locomotive. The valve travel was 35 per cent in both sets of cylinders, and steam chest pressure 265 lb h.p. and 73 lb l.p., the ratio h.p. to l.p. is 1 : 2·44. At the top of this heavy gradient the speed had only fallen to 50 m.p.h., with the cut-off lengthened to 50 per cent.

Very fine work with 630 tons. Over the summit the speed quickly rose to the 110km limitation. It was delightful riding in the cool of the evening through the lengthening shadows, with the sun out of one's eyes, right behind, and the wind deflectors in front of the windows were very useful. The riding was so good I cannot help referring to it again ; really surprising, bearing in mind the comparatively small driving wheels, only 5ft 4½in diameter, which were turning over hurriedly, yet when I leant out of the cab and watched the motion, almost blurred at this speed, listening for any evidence of stress, there was none whatever—not a knock or a hiss—100 per cent efficiency. They can certainly do it in France, but how, I don't know ! We were making some fairly fast running now, though throttled by the 68 m.p.h. limitation, and things were going to be comparatively easy right to St. Germain, nearing Dreux.

A stop was made at Sainte-Gauburge, 7.58, only 3 min late ; this station had been run through going west. The 16 miles from Surdon had taken 19 min and had included heavy climbing. It was mentioned to me that trains are not allowed to get more than 3 min ahead of time. Every between-station stretch showed some time had been picked up, and we were already nearly back on schedule. French drivers are given a bonus for time recovery ; Le Boucher ought to do well out of this run, I thought ! I do not say P232 was being thrashed, but it was certainly being made to realise that " life was stern, life was earnest " on occasion, and this was one of them. Mounting the 1 in 100 gradient

referred to in the preceding paragraph, Monsieur Boit had worked out the following figures : the engine had developed roughly 2800 h.p.—its maximum is 3500—resulting in a 15-ton pull at the drawbar. I have not checked these figures, nor do I mean to do so —armchair critics will undoubtedly save me the trouble.

Laigle, and a stop, 8.11, still 3 min late ; water was taken here, and the 5 min halt was extended to 6 min ; we left at 8.17, 4 min late. During this pause, getting down to stretch my legs and wandering round in front, I had found three plump partridges lying on the buffer-beam, like manna from Heaven, and was given an enthusiastic reception in the cab on presenting them to the enginemen—who probably had supreme moments with their *bonnes femmes*—I hope that is right—on getting home that

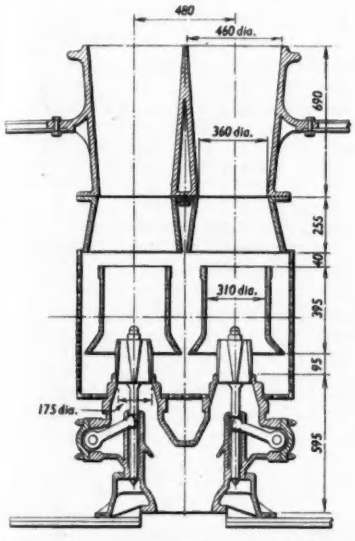


Fig. 27—Kylchap Double Chimney, with Adjustable Nozzles

night. The following appears in my notebook regarding the get-away from Laigle : "Acceleration from standstill phenomenal—picked up in spectacular fashion—with 630 tons." The effect of the partridges, no doubt.

Bourth was passed at speed ; 9 miles in 9 min, only 1 min late, and the succeeding 5 miles to the stop at Verneuil-sur-Avre were covered in 5 min, where the train came to a stand at 8.32, O.T. The 14 miles from Laigle had been made at an average start to stop rate of 60 m.p.h., the fastest done anywhere during the afternoon, and the 17 min we had been behind on leaving Argentan had been recovered in 47½ miles, though two stops were included in the distance. Very good work from a mixed traffic engine hauling 630 tons. Another enthusiastic entry is found in my notes : "Engine in perfect shape—every gland tight as a drum—motion absolutely silent. Electric light switched on—why haven't we got it ? Are we so broke—don't believe it—habit—done without it so long can go on doing without it." These musings were brought to an end by arrival in Dreux at 8.59, 1 min early. The preceding 22·5 miles had been covered in 25 min and the 72 miles from Argentan, inclusive of four stops totalling 14 min, in 80 min. Deducting the 14 min, but making no allowances, the average had been 54 m.p.h. I give all these times and distances because in this case they are really informative, bringing out the high speeds between stops, and how lost time was determinedly and successfully regained, notwithstanding a permitted maximum of only 68 m.p.h. I am glad the start from Argentan had been 17 min late, as it gave everyone concerned, including the engine, an opportunity of showing how such a handicap is regarded on the S.N.C.F.—as something to be cancelled out if at all possible. In Britain I must confess I have seldom seen any corresponding effort to make up lost time—the "Capitals Ltd." is an exception. I am not overlooking the fact that it is much harder to do it here, owing to traffic congestion ; once a train gets behind time it may be impossible to recover it without overtaking something in front. But the general attitude towards time-keeping seems different in France ; perhaps the bonus given for recovery accounts for this.

Dreux was left at 9.03, 1 min behind time ; of course, there was no semblance of a slip—I don't know how they do it ! There was heavy work ahead of us now, with only a few "rest-and-be-thankfuls" before Fontenoy was reached and Paris nearly in sight. With fine acceleration we were soon rushing through the warm evening air, the country again inducing nostalgic memories, looking more Manitoba-like than ever as the gathering dusk deepened over the golden fields. Heaven forgive me for admitting this feeling, in spite of having fallen in love with *la belle* France ! But there—I have known prairie people say they did not like Victoria, B.C. Verily, there is no accounting for tastes ! Again, the slowing for relaying near Montfort ; I was beginning to feel a little tired, after standing for seven hours with only the one break at Argentan, so gave up note-taking, finding a perch on the tender, the only seat available. A check to 20km passing St. Cyr, then rapid pick-up with the lights of Paris ahead. Versailles—Chantiers, and a stop, 9.54 O.T. ; away again towards the red light of the Eiffel Tower, crossing many brilliant boulevards streaked with headlights, to a final stand in the Gare Montparnasse at 10.11, dead on time. A very fine run, most enjoyable and flawless, as I acknowledged to the quartette in the cab, to their evident pleasure. The 118 miles from Argentan, inclusive of six stops totalling 16 min, had taken 2 hr 44 min, an average of 42·5 m.p.h. ; exclusive and making no allowances for slowing to and getting away from stops, 47·2 m.p.h. There may be equivalent work done in Britain but, if so, I am not aware of it ; the timing and measuring pedants will no doubt enlighten me on this point in due course, when I will sit corrected.

After exchanging mutual farewells, Monsieur Boit left to catch a night train back to his duties at Caen ; he, too, was tired, as well he might be. I left for the Metro, *en route* for the Gare St. Lazare and Asnières. Deprived of his invaluable guidance and new to the Underground, I at once ran into trouble. On presenting my ticket at the barrier, instead of letting me through, the collector detained me and began to talk—I was sunk. What could be the matter ? Tired, impatient, and somewhat irritated, I appealed to the crowd : "Is there anyone here who speaks English ?" There were no returns, but a bystander pressed a ticket on me, which satisfied the man at the barrier, and I was waved through ; on looking round for my friend in need, to thank him, he had disappeared. Recuperating in the electric train from St. Lazare to Asnières, with ruffled plumage smoothed and tired brain beginning to function again, I looked at the rejected ticket and immediately the fog cleared—a ticket from St. Lazare to Asnières is not valid between Montparnasse and St. Lazare ! *Oui, c'etait ma faute !*—it generally was when things went wrong. At any rate, I wouldn't make that mistake again—my troubles for the day, I felt, were over. Not a bit of it—the ticket-collector at Asnières was not satisfied either—he began to talk, too. *Now* what was wrong ! Nothing penetrating the solid wall of my obtuseness, finally he laughed and, taking my arm, led me to a little machine fixed to the wall of the waiting-room, inserted the ticket in a slot, pulled a handle and — *Mon Dieu !* it was stamped ! It seemed I should have done this for myself at the Gare St. Lazare—another lesson learned, another stile surmounted, and in an atmosphere of merriment and *bonhomie* the *entente cordiale* was strengthened and I emerged into the street. These incidents typify the little difficulties one gets into when touring France inhibited by lack of acquaintance with the language both of diplomacy and the S.N.C.F. ; but thus hampered, though one cannot be diplomatic, one can at least be appreciative and friendly—the response will be immediate and charming.

(To be continued)

Symposium on Gas Absorption

THE Institution of Chemical Engineers is holding a symposium on gas absorption from April 5th to April 7th at the University, Edgbaston, Birmingham. In all seventeen papers are to be read. Amongst the papers on centrifugal gas absorption is one by B. E. Dixon, "Some Aspects of the Absorptive Mechanism in Centrifugal Absorbers" ; one by H. H. Chambers and R. G. Wall, "Some Factors Affecting the Design of Centrifugal Gas Absorbers" and another by J. F. Alcock and B. W. Millington, "A Double Rotor Centrifugal Absorber."

In the first of these three papers the author describes laboratory studies of various aspects of absorption in a centrifugal absorber and some conclusions are drawn as to the factors governing these processes.

In the second paper an experimental study has been made of a new type of gas absorber and of the factors influencing its performance. The mode of action of the absorber is elucidated and the basic design principles established. An absorber with a diameter of 21in and a height of approximately 10in has been found able to treat at least 21,500 cubic feet per hour of air containing 14 per cent of carbon dioxide, reducing the carbon dioxide content to 2·5 per cent, with a consumption of 225 gallons per hour of monoethanolamine.

In the third paper a centrifugal gas absorber is described in which a very active but viscous absorbent may be used effectively. In tests on this apparatus where carbon dioxide is absorbed in concentrated monoethanolamine, high values for the absorption coefficient are realised. Developments of this apparatus are proposed.

Other papers include "The Cooling and Dehumidification of Air with Refrigerated Brine in a Grid Packed Tower," by W. S. Norman, M. O. Algawi and F. H. Garner ; "Applicability of the Results of Small Scale Experiments to the Design of Technical Apparatus for Gas Absorption," by P. J. Hoftyzer and D. W. Van Krevelen, and "The Pressure Drop Characteristics of a Grid Tray," by F. H. Garner, S. R. Ellis and Z. Bershadsky.

THOS. W. WARD, LTD.—To mark the seventy-fifth anniversary of its inception, Thos. W. Ward, Ltd., of Sheffield, has published, for limited distribution, an interesting book entitled *Outline of Progress*, 1878–1953. This firm was started by the opening of a small business for the sale of domestic coal and coke in Sheffield by Thos. W. Ward. The book tells how, with the expansion of his interests, Thomas W. Ward was later joined by his two brothers, Joseph and Arthur, and how from a small start in the scrap trade the dismantling and shipbreaking organisation grew to its present considerable proportions. The book describes the establishment and growth of the other sides of the firm's interests in connection with the supply of raw materials, plant and machinery, contractors' plant, railway equipment, &c., and its industrial and engineering services. Particulars are also given of the many subsidiary and associate firms in the "Ward Group" and their work.

Research Station for Short-Circuit Testing of Switchgear

On March 23rd Lord Citrine, chairman of the British Electricity Authority, formally opened the new Reyrolle research station for short-circuit testing and allied work. In this station use is made of the two existing generators, which can be paralleled on the e.h.v. side with a new machine of 60MVA nominal capacity. Various short-circuit test outputs are obtainable, up to 4800MVA equivalent three-phase output with $E/\sqrt{3}$ recovery voltage, on single-phase tests, within a voltage range of 66kV to 380kV. There are two indoor test bays and one outdoor, with preparation facilities in an adjoining erection bay. Control is effected from a central building equipped with recording equipment, observation rooms, offices and ancillary services for the preparation of reports on tests.

THE new research station for short-circuit testing, which was opened at Hebburn-on-Tyne on March 23rd by Lord Citrine, represents a quarter of a century's experience in the development of high power switchgear testing facilities by A. Reyrolle and Co., Ltd. For it was nearly twenty-five years ago, in 1929, that this company, as a manufacturer of switchgear, commissioned the first regular, commercial short-circuit testing station in Great Britain.*

To meet the need for increased short-circuit capacity the station was extended in 1934 and its equivalent three-phase output, obtained in single-phase tests, was raised to about 1100MVA at the higher voltages (up to 132kV). Since then the demand for switchgear with higher rupturing capacities has grown so rapidly that these testing facilities were becoming inadequate for supplying the kind of information that was necessary for developing the most economical designs of new switchgear. Soon after the last war this handicap was becoming serious and it was clear that a much larger testing plant was required. It was recognised, however, that it would be uneconomic to provide short circuit outputs equal to the rupturing capacity of some large modern circuit breakers, such as 10,000MVA at 275kV, and alternative testing techniques had to be sought. Fortunately good progress had been made in developing the method of unit testing. As unit tests usually can be made on a single phase and are, therefore, generally suitable for large circuit breakers, this technique offered a suitable basis for the design of the new plant.

With the power available in the new research station the company believes that it will be in a position to make full-scale, three-phase, single-phase or unit tests capable of proving most forms of switchgear likely to be built in the foreseeable future.

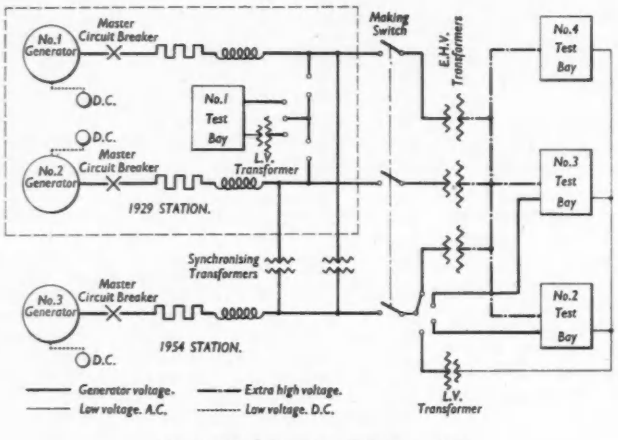


Fig. 1—Main Circuits of Testing Plant

Official Opening of Station

In a brief opening ceremony on Tuesday, March 23rd, the guests were welcomed in the station observation room by Sir Claude Gibb, the chairman of the company, who handed Lord Citrine, the chairman of the British Electricity Authority, a "Permit to Work," authorising him to close a 275kV air-blast circuit breaker by depressing a push-button. After closing the switch Lord Citrine unveiled a commemoration plaque on the wall of the observation room.

As a prelude to a tour of the testing station the company's guests were given a short technical description of the station (followed by a film showing some of the constructional stages) by Mr. J. F. Bird, engineer-in-charge of the testing and certification department. Demonstrations were also given of high power arcs; the first demonstration showed the interruption of an arc in air, carrying 6000A at 152kV to earth, interrupted by a 275kV air-blast circuit breaker in 0·06 seconds, the normal operating time of the breaker; in the second demonstration the same circuit breaker was shown interrupting the arc after allowing it to persist for one second, simulating an uncontrolled fault arc on the 275kV grid.

Arrangement of Plant

The main purpose of the station is to provide the greatest possible single-phase outputs, but provision is made for producing three-phase short circuits of high output at voltages up to 275k.

These high single-phase outputs are attained chiefly by four expedients:—

(1) Use is made of the fact that, in single-phase circuits, with all transformers connected in parallel, the lowest plant reactance can be obtained.

(2) The generators are arranged in so-called "U" connection (for example, as in Fig. 3). This is a single-phase arrangement using all windings in such a way that the reactance is reduced and the single-phase output of each generator is increased by at least 33⅓ per cent.

(3) Over-excitation is provided to ensure a high recovery voltage and correspondingly high currents during test, whereby the maximum benefit can be gained from the "U" connection.

(4) By arranging to apply the short circuit at any selected point of the voltage wave, complete control is maintained over the degree of asymmetry, making it possible for symmetrical tests to be made immediately after the start of the short circuit and before the sub-transient component of the current has died away.

The electrical arrangement of the plant is outlined in Fig. 1, and a typical e.h.v. connection is shown in Fig. 3.

Three short-circuit generators, together with their associated over-exciter sets, provide the source of power. Each machine has its own master circuit breaker, current limiting reactors, resistors, and making switch, and normally feeds its own group of e.h.v. transformers.

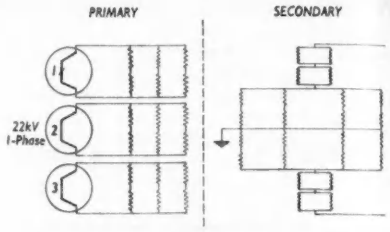


Fig. 3—Alternator and Transformer "U"-Connections for 304kV, 1-Phase (for 380kV, 3-Phase Gear)

To avoid the very large currents which might otherwise flow in the event of a generator fault, the short-circuit generators are normally paralleled on the e.h.v. side of the transformers. This necessitates the provision of an auxiliary synchronising tie to hold the machines in parallel prior to the application of the short circuit. For this purpose two single-phase, 500kVA transformers are used, as shown in Fig. 1.

Arrangements are also made to supply the test bays with power at generator voltages, or through a step-down transformer: the latter is intended mainly for short-time current-carrying tests where it may be necessary to maintain a heavy current for times up to five seconds. It can also be used for testing medium voltage switchgear, although most of this work will continue to be done in the 1929 station, which is being kept in commission as a generating station and for testing at all voltages up to 22kV.

The above-mentioned plant is housed in a series of steel-framed brick and concrete buildings so arranged as to keep conductor runs as simple as possible and to give clear access to all parts. Allowance has also been made for the possibility of future extensions.

The layout is illustrated in Fig. 2, from which it will be seen that the buildings are grouped about the test bay block (centre), which also

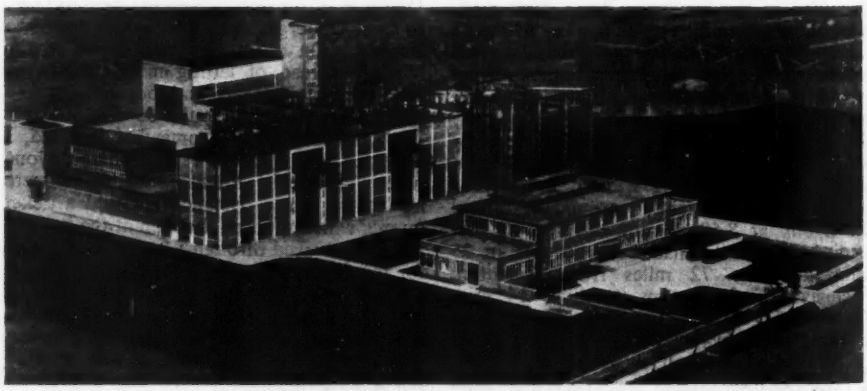


Fig. 2—Research Station Showing Generator Room (left), Two Indoor Test Cells and Open Test Area (centre). In the Right Foreground is the Administration and Observation Room

* The Engineer, December 30, 1932.

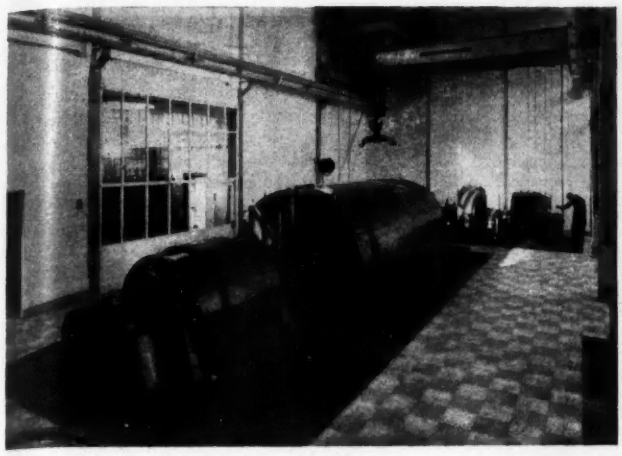


Fig. 4—Short-Circuit Alternator with Flywheel Exciter Set in the Background

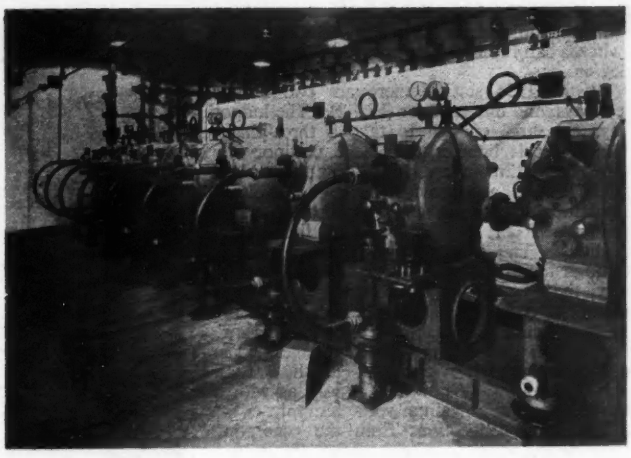


Fig. 5—Three 3-Phase Making Switches

houses the making-switch from which the main connections radiate to all parts of the station. The control building is sited (right, foreground, Fig. 2) in front of the test bay block, at a distance of approximately 100ft, while the heavy plant is installed immediately behind it (left, Fig. 2).

Road and rail access is obtainable to all test areas and they communicate with the erection shop, sited conveniently nearby (left, background, Fig. 2). The rail sidings have also been so arranged that they may be used for the handling of any of the heavy items of plant, should the need arise.

The natural fall of the ground has been used to improve observation of the tests and also to provide a measure of protection between the test bays and the safe areas.

Outputs

The maximum output of the station is obtained, naturally, with full excitation or over-excitation. which means that it will be obtained at certain fixed voltages ; the voltages include those in use in Great Britain and others used abroad. At all these voltages, within each range, the output is substantially constant. A summary of the output capacity of the plant is tabulated below.

Table—*Output Capacity of Reyrolle Research Station*

Voltage range	Three-phase or single-phase	Output
Up to 22kV	Three-phase	2000MVA
33kV to 275kV ...	Three-phase	1500/2500MVA
66kV to 380kV ...	Single-phase ...	3200MVA* (with $1{\cdot}5E/\sqrt{3}$ recovery voltage) 4800MVA* (with $E/\sqrt{3}$ recovery voltage)

* Equivalent three-phase output.

Generating Plant

Short-circuit power is provided by three Parsons generators. The third machine (Fig. 4) has the largest output and its main particulars are as follows :—

Frame size	60MVA
Stator weight	74 tons
Rotor weight	23 tons
Speed	3000 r.p.m.
Induction driving motor	1200 h.p.
Reactance...	4 per cent

The ventilation ducting is reduced to limit the leakage reactance of the machine. The other two machines† previously supplied by C. A. Parsons and Co., Ltd., are similar in size and appearance, but their windings are arranged differently and their output is slightly lower.

All three generators are arranged with two windings per phase, which can be connected in series or parallel, star or delta, to give the four basic three-phase voltages of 6·35kV, 11kV, 12·7kV and 22kV. Intermediate voltages are arranged by excitation control. The "U"-connection (Fig. 3) is also available to give 19·1kV with normal excitation and 22kV with over-excitation.

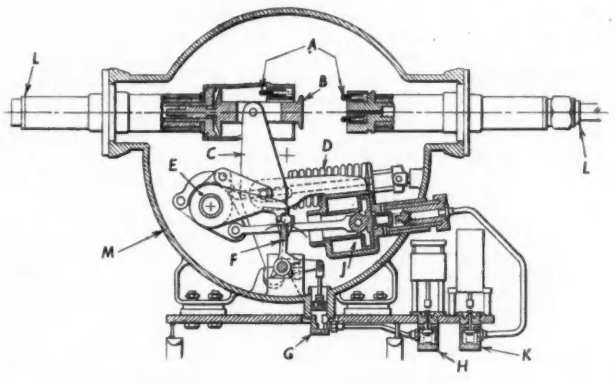
The over-exciter set for No. 3 generator is also driven by an induction motor. Its characteristics are as follows : output, 1600A at 625V (this current can go up to 3000A during short circuit of the alternator) ; speed, 750 r.p.m.

A 12½-ton flywheel is provided to improve the characteristics during short circuit. The over-exciter sets for Nos. 1 and 2 generators are similar, but are mounted on a common driving shaft.

To avoid imposing repeated sudden loads on the supply system, the driving motors of the main sets are disconnected before the short circuits are applied. It is thus necessary to reconnect the sets and bring them up to speed again before each test. This is easily done from the control room by inserting small resistances in the slipring circuits of the motors before connecting the supply. These resistances are finally short circuited when the sets are nearly up to speed.

Synchronising of the three sets is first effected with low excitation. Enough power can be generated in this way to hold the machines in step on no load, and when the excitation is raised under hand control care is taken to ensure the generated voltage of each machine is the same.

For the test at the highest output over-excitation is needed and a timed sequence is introduced. After normal excitation has been adjusted by hand on open circuit, the over-excitation process is initiated with a number of definite time-lag relays operating in conjunction with the test-sequence controller. The over-excitation takes place in two stages : first the exciter field is boosted and then the main field is boosted. At a predetermined instant, calculated from the known excitation characteristics of the machine, the short-circuit test is applied.



A—Fixed contacts. *B*—Moving Contact.
C—Contact lever (B paper). *D*—Operating spring.
E—Main drive shaft. *F*—Tripping latch.
G—Tripping relay cylinder. *H*—Trip valve and magnet.
J—Spring charging piston. *K*—Charging valve and magnet.
L—Terminals. *M*—Pressure tank.

Fig. 6—Section Through One Pole of Making Switch

Switchgear

The main feed to the plant and the supplies to the 5·5kV induction motors are controlled by Reyrolle standard class-C switchgear with a rating of 150MVA at 5·5kV. D.c. switchgear for controlling the field currents has been specially designed for this duty and the larger units may have to break currents up to 3000A at about 1·5kV, with an appreciable 100 c/s current superimposed. The master circuit breakers are a development of the standard Reyrolle class-R switchgear, and are fully phase separated. They can break the full output of the generators at any voltage. This involves currents of 50kA at 22kV, and 80kA at 11kV.

Current Control

Current is controlled by reactors and resistors. The resistors are used mainly to adjust the power factor. The reactors are arranged in two groups. Those for controlling the short-circuit current consist of air-cored coils in stacks of three. They are provided with tapping points and self-locking isolator links permit rapid circuit changing. The reactors for controlling currents in the load-current range are three-phase, iron-cored units, giving a range of 5A to 250A at 11kV.

Short-Circuit Application

Normally, short circuits are applied through the making-switches (Figs. 5 and 6), which consist of three three-phase units (one for each generator). These switches close at any selected point of the voltage wave. They have, therefore, been designed to precision limits.

To reduce arcing before make, the contacts are enclosed in compressed air at 150 lb per square inch. The speed of make is high and contact is first made between the left fixed contact (*A*) and the left-hand face of the moving contact (*B*), and then by the right-hand contacts. Operation is by pneumatically-charged springs. All nine poles can be ganged mechanically with clutches between groups of three. They are capable of making currents up to 150kA peak.

Control is exercised through a thyratron, triggered from a 440V supply in synchronism with the main sets and tied in with the main test sequence through the master controller

† The Engineer, October 29, 1937, pages 471–473.

Experience so far gained with the making switches indicates that timing of the ganged switches can be controlled to within 10 electrical degrees.

At the 1954 station there are two indoor test bays, and one outdoor (Fig. 2). The indoor bays are large enough to take a three-phase, 132kV circuit breaker, while the outdoor bay can take a three-phase, 380kV circuit breaker. All the bays are provided with low voltage auxiliaries, measuring cables, overhead crane, compressed air, switch oil and fire-fighting facilities. The indoor bays have rear access through reinforced steel swing doors. If necessary, these bays can be completely shut off by means of motor-operated roller shutter doors at the front. Main circuit connections are brought to these bays at all voltages. The outdoor bay is provided with supplies at all voltages from 33kV upwards, as well as with a low voltage and a medium voltage supply.

The main connections from the generating units to the making-switch consist of two 0·5 square inch, three-core cables in parallel per unit. Similar cables connect the making-switch room to the e.h.v. transformers. These cables run the length of the test bay block, via a subway which also carries oil, water and compressed air supplies, and control cables.

A connection room at the side of each test bay houses the short-circuit point. Current measuring equipment and associated gear is installed here. One of these rooms also houses the two synchronising transformers.

The e.h.v. transformer bank comprises twelve single-phase Parsons shell-type 11/38kV transformers and three single-phase Parsons shell-type 11/152kV transformers (Fig. 7). The reactances are as follows : 152kV transformers, 3 per cent on a 50MVA frame size ; 38kV transformers, 3·3 per cent on a 12·5MVA frame size.

The 152kV transformers are provided with two primary windings, for 22kV or 11kV, and four secondary windings, each 38kV, which can be connected in four series-parallel arrangements to give 38kV, 76kV, 114kV and 152kV. This method of connection keeps the transformer output almost constant, irrespective of the voltage. The windings are made up of pancake coils and the core axis is horizontal. The different arrangements are selected by oil-immersed switches.

On the primary side of all transformers the connections are open and circuit changes are made through self-locking isolator links, similar to, though larger than, those used with the reactors. E.h.v. connections are switched by standard rotary isolators.

The auxiliary equipment provided includes d.c. generator sets and batteries for tripping and closing purposes, compressors for the operating of pneumatic gear and condensers for the control of R.R.R.V. The compressors are oil-cooled and operate up to 1000 lb per square inch, the air then being cooled to take off surplus moisture and then expanded to about 600 lb per square inch, at which it is available for use as dry air.

Switchgear is prepared for test in an erection bay (Fig. 2) situated a short distance from the test bays, where workshop and crane facilities are available, together with the means for making preliminary tests on the gear before it goes to the test bay. A " Giraffe " tower ladder is available to give access to high gears. Smaller switchgear is normally erected on flat-topped switch trucks which can be wheeled into the bay and rapidly connected up. Larger gear can be prepared only partly in the erection bay and is finally assembled in the test bay. The erection bay also houses many of the domestic services such as central heating plant and oil-handling plant.

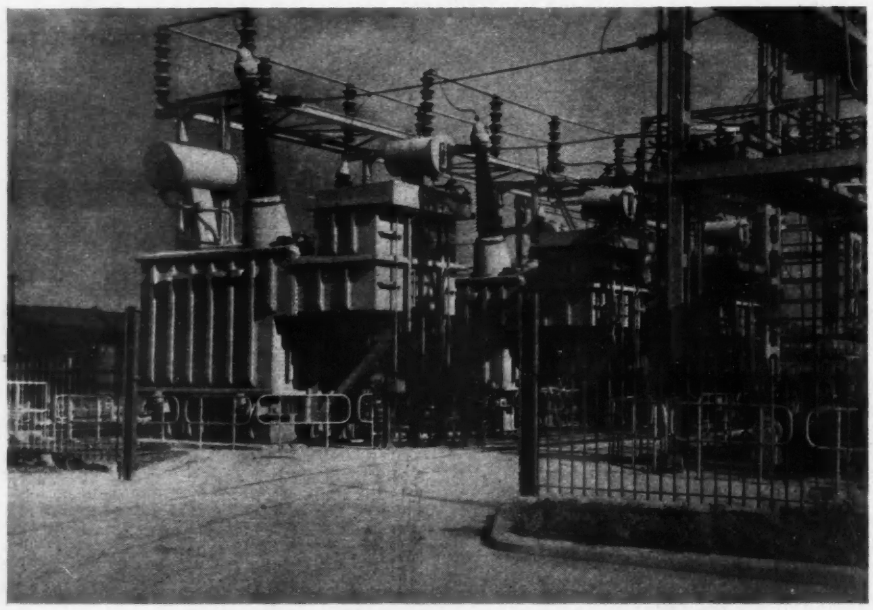


Fig. 7—Single-Phase Shell Type 11/152kV Transformers

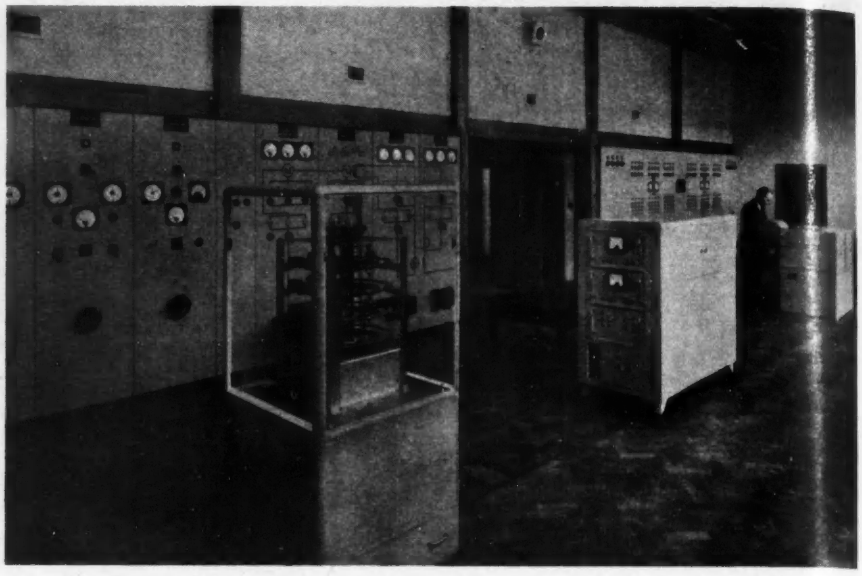


Fig. 8—Control Room with Main Control Boards, Test Sequence Timer, Cathode Ray Oscillograph and Electromagnetic Oscillograph

Control and Measurement

Accommodation.—Control is exercised from a central building, which also accommodates recording equipment, observation rooms, photographic dark rooms and offices. One of the observation rooms also serves as a lecture theatre.

The Control Room.—In the control room (Fig. 8) the main control boards are arranged along the back wall. The electromagnetic oscillographs and cathode-ray oscillographs and the test sequence timer are in front. The cathode-ray oscillograph comprises four 10kV sealed tubes and records are obtained photographically on a rotating drum. The test sequence controller was designed to exercise individual control over the three generators and their exciters and for co-ordination of the test sequence. It consists of four radial arms, impelled by a spring and rotating in a horizontal plane to operate lightly-set contacts mounted on a graduated circular scale. Up to thirty-six contacts may be operated in this way and a wide range of speeds is available.

The test control engineer operates from a position with a commanding view of the test bay and the nearby areas and has a simplified panel with a mimic diagram which indicates the plant in use and the position of the earthing switches. Prior to the test, circuits are checked on a supervisory panel which ensures that individual items of plant are not over-loaded and that the circuit will produce the required current. Safety interlocks and a warning beacon for the test area are provided.

Photography.—Extensive facilities are provided to deal with the many photographic techniques in use. The more important of these include : (*i*) low-speed records from the electromagnetic oscillograph ; (*ii*) high-speed records from the cathode-ray oscillograph ; (*iii*) normal speed cine records of the gear during test ; (*iv*) high-speed cine records especially of individual components during test ; (*v*) still photographs of the condition of the gear at the various stages of test ; (*vi*) many kinds of reproduction.

Oscillographic records expanded up to 1 microsecond=6cm can be obtained.

Reporting.—The last stage in a test series is the report of performance (issued under the auspices of A.S.T.A.) containing a complete record of the performance, together with photographs, drawings and oscillograms.

Contributors to the Installation

The consultants for the research station were Messrs. Merz and McLellan ; the architects were Messrs. Cackett Burns, Dick and MacKellar ; the main contractor was Alex. Anderson (Contractors), Ltd.; the sub-contractors were ; steelwork, Wright Anderson and Co., Ltd. ; heating, G. N. Haden and Sons, Ltd. ; lighting and wiring, Fairbairn and Partners, Ltd.

The main suppliers of equipment were :—

Generators, power transformers and reactors, C. A. Parsons and Co., Ltd. ; switchgear, controls, m.g. sets, copper work and cathode-ray oscillograph, A. Reyrolle and Co., Ltd. ; cables and condensers, British Insulated Callender's Cables, Ltd. ; d.c. switchgear, Bertram Thomas (Engineers), Ltd. ; starters, Allen West and Co., Ltd. ; electromagnetic oscillographs, Cambridge Instrument Company, Ltd. ; capacitance dividers, Dubilier Condenser Company, Ltd. ; batteries, Nife Batteries ; pressure test transformer, Foster Transformers, Ltd. ; fire-fighting equipment, Walter Kidde and Co., Ltd. ; compressors, Hamworthy Engineering Company, Ltd. ; cranes, John Smith (Keighley), Ltd. ; " Giraffe " tower ladder, Wm. Moss and Sons, Ltd. ; telephone system, Siemens Brothers and Co., Ltd.

Radiator Core Making Plant

A design of radiator core particularly intended for replacing damaged cores on a wide range of industrial equipment on sites where spares are not readily available has been developed by J. W. Lawrence, Ltd., of Leicester. For the manufacture of the cores this firm has also developed a plant which is simple to install and operate in depots and small workshops concerned with the maintenance and repair of equipment. This plant is equally suited to making the cores for radiators for new equipment.

IN highly industrialised countries where plant is used in reasonably close proximity to the place of manufacture, the problem of replacements in the event of a breakdown is not often particularly acute and rarely involves keeping valuable equipment out of service for a very long period. But in countries where the equipment is not manufactured, and is often used on sites remote from industrial centres, the problem is one of outstanding importance, as spares have to be shipped long distances and the time lost can be considerable. One of the frequent causes of such delays now that internal combustion engines are used as a source of power for so much equipment, is damage to cooling water radiators. These radiators are of necessity built up of flimsy materials and generally to function effectively they are set in positions where they are exposed to damage. The wide variety of sizes and types of radiators fitted on plant is such that it is virtually impossible, and often quite uneconomic, to maintain a fully comprehensive stock of spare blocks. For this reason, a damaged radiator can keep a piece of valuable equipment out of service for a long period on a remote site whilst makeshift repairs are carried out or replacements are obtained from distant towns or even overseas.

This problem was brought to the attention of J. W. Lawrence, Ltd., Leicester, some three or four years ago by its Canadian works, which

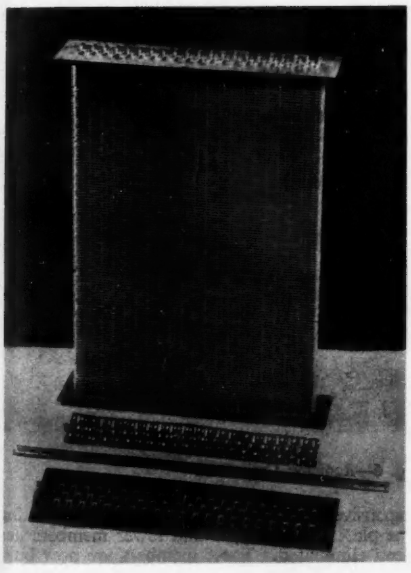


Fig. 1—Complete Radiator Core, Fin Element, Tube and Header Plate

specialises in the repair and maintenance of aircraft radiators. As a result of detailed investigation the firm decided to design a form of radiator core adaptable for application to the widest possible range of industrial equipment and develop a simple and economic plant for the manufacture of such cores. A suitable design of core was developed, and now, as a result of two years' experimental work with prototype machines, the firm is building plant comprising a group of basic machines which can be installed at remote maintenance depots and operated by local labour to make radiator cores in any size up to 30in by 36in for all classes of equipment.

The standard radiator core developed can be seen with its component parts in the illustration, Fig. 1, on this page. Each core consists of an assembly of rectangular tubes, $\frac{1}{16}$in by 0·120in, coupled together by fin elements and top and bottom header plates. In each row the tubes are spaced at $\frac{1}{8}$in centres and the successive tube rows adjoin without spacing, the tubes being staggered at half pitch centres. Cores can be made with two, three, four or five rows of tubes, and if thicker cores are required they can be built up from multiple units and coupled by common header plates. The fin elements can be spaced to suit the required conditions. It will be noted that between each tube the fin element is dimpled, and this dimpling gives an appreciable increase in the heat dissipation properties of a core. In tests carried out with cores on an aircraft radiator test rig it was found that this form of construction gave a high resistance to vibration and hot pressure cycling, and the cores effectively withstood accelerated life tests which imposed stresses beyond those normally encountered in industrial service.

The basic pieces of equipment which have been developed for making radiator cores from the essential strip materials are shown in accompanying illustrations. They include a fin element making machine; a tube making machine, with an associated preturning unit and a cutting off attachment; a header plate press tool set; a core assembly jig, and an oven. With the standard equipment cores with two, three, four or five rows of tubes, can be made, and, if required, it can be readily adapted for making six-row cores. If thicker cores are required, they can, as mentioned above, be built up from multiple units and coupled by common header plates.

The fin elements are made on the machine shown in Fig. 3. In this machine strip fed from a coil is first folded over along the edges, to form a reinforcing hem, then pierced, flanged and dimpled, and finally cut to length. The machine, which is driven by a $\frac{1}{4}$ h.p. motor, is capable of producing up to 40ft of element a minute. In it the strip is first drawn through a hemming tool on a platform in front of a set of toothed rollers, and in this tool the edges are turned over and flattened. The two edge folding elements

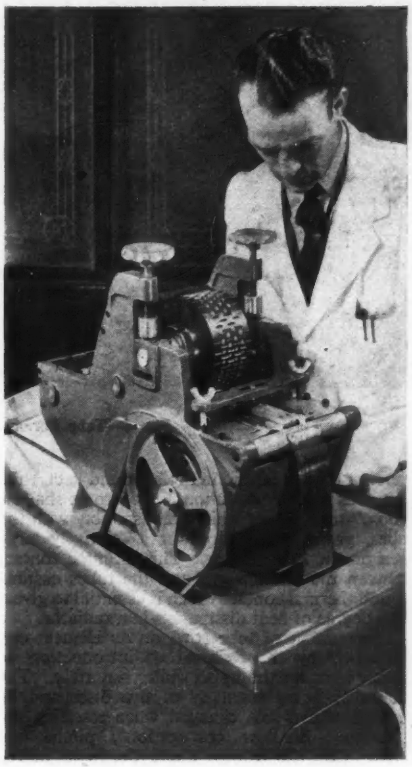


Fig. 3—Fin Element Rolling Machine

of this tool can be positioned in accordance with the width of strip required for making two, three, four or five-tube row elements.

The lower roller of the machine is essentially a rotating die assembly, and the upper member the corresponding punch. The punch roller is an assembly of discs locked together on an alloy steel shaft. Each disc has projecting from its circumference alternate dimpling punches and combined piercing and forming punches. This punch roller shaft rotates freely on its bearings whilst the die roller is driven through gearing, and the drive is transmitted through its projecting punches to the upper member. As the material is drawn between the rollers its length is alternately dimpled by one set of punches and then pierced by the next set of punches in staggered rows. The punches are so designed that after

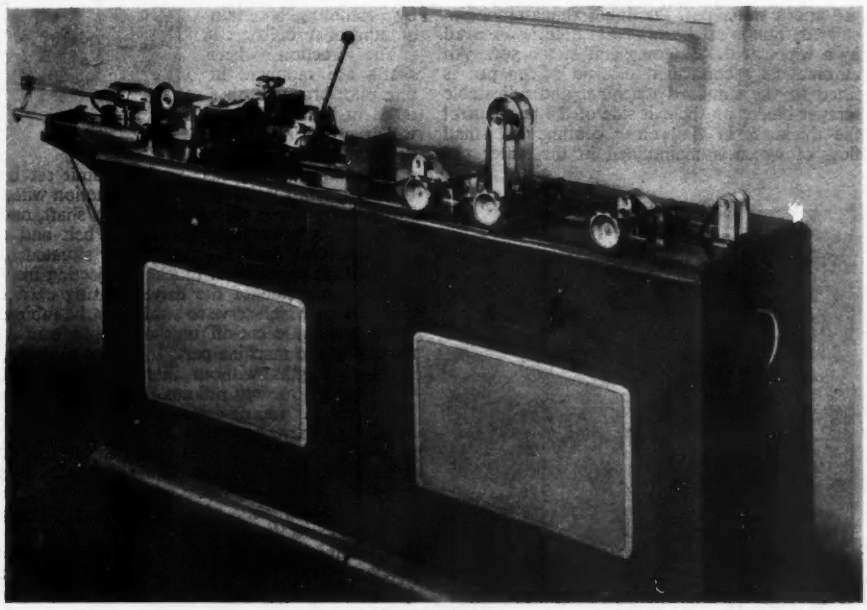


Fig. 2—Tube Tinning, Forming and Cutting Machine

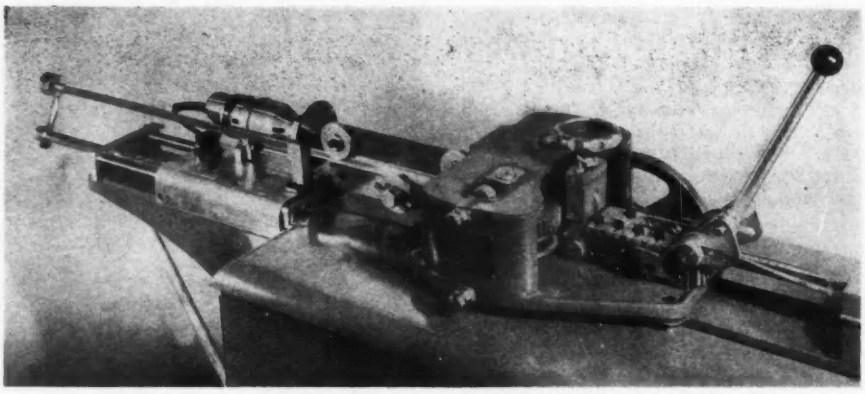


Fig. 4—Tube Forming and Cutting Machine

piercing they bend the material round each tube outwards a sufficient amount to form a shallow " box," the sides of which, on assembly with the tubes, give a light grip over a relatively large area on the tube surface. This intimate contact between the fin elements and the tubes ensures a good thermal contact which is essential to give a high degree of heat dissipation in a radiator.

The number of tube rows on an element can be varied by the removal or introduction of punch discs on the upper roller assembly. The die roller is an assembly of five discs and its arrangement is not changed when resetting the machine. Shallow corrugations, pitched at $\frac{1}{4}$in centres, are formed along the hems of the elements by die discs flanking the discs on the upper roller members. These corrugating punches register with the piercing punch depressions in the lower roller assembly when the upper roller is arranged for producing two or three-tube row elements. The die and punch discs are hardened and ground, and hard chrome-plated to give a longer working life.

As the strip of punched and formed material passes out of the machine elements are cut to the required lengths by a guillotine. This guillotine is actuated by a cam through gears driven from the lower roller shaft. The gears can be easily and quickly changed to cut the elements to different lengths, and a fine setting mechanism is fitted to give a small range of adjustment.

Tubes are made in a three-stage machine in which strip is tinned, formed and lock seamed and then cut to the required lengths at a rate of 30ft to 40ft a minute. This machine is illustrated in Fig. 2.

In the tinning unit, the coil of tube strip is mounted on a holder in the cabinet base and is drawn in succession through a flux pot, a solder pot and a water pot. A liquid zinc/ammonium chloride flux is used and excess fluid is removed by a wiper at the outgoing end of the pot. An automatically controlled electric solder pot is fitted to the standard machine, and adjustable scraper blades on the exit side of the pot control the thickness of the solder coating. A small flow of water is maintained in the water pot where the strip is cooled and washed before passing on to the tube-forming machine.

In the next machine the tubes are formed by drawing strip through the assembly to be seen in Fig. 4. At the leading end of this assembly there is a block containing a series of forming dies which convert the material into lock-seamed tubing over a central mandrel. A loaded roller at the outgoing end of the die block imparts a final closing pressure on the tube seam. The hardened and ground mandrel can be withdrawn by operation of a lever to facilitate initial strip loading when starting a run.

The tubing is drawn through the machine by a pair of wheels mounted on vertical shafts in the housing just beyond the die block. Flanges round the upper and lower circumferences of these hardened steel traction wheels have shallow teeth machined in them. As the wheels press inwards on the tubing their teeth provide a positive grip to draw the strip through the dies and the pre-tinning unit. The wheel teeth impart a continuous track of shallow depressions along the upper and lower faces of each side of the tubing, and the makers state that these minute corrugations serve to increase heat transfer properties of a radiator by promoting a certain amount of turbulence.

The traction wheel shafts are mounted in phosphor bronze bushes fitted in bearing blocks which are spring loaded so that the driving pressure can be adjusted up to a limit set by fixed stops in the housing. Each traction wheel is driven by a gear wheel keyed to its shaft, and the drive is transmitted through a belt and a reduction unit from a $\frac{1}{2}$ h.p. motor situated in the machine cabinet. A bracket projecting from the outgoing side of the drive housing carries three rollers which serve to straighten the tubing.

An automatic cut-off unit on a platform at the end of the machine parts the tubes off in the required lengths without interfering with the continuous forming process. In this unit a 1,800 r.p.m. motor-driven saw is supported by a hinged arm on a light alloy carriage which moves on ball bearings along a pair of ground tubular tracks. As the saw carriage moves rearwards along its tracks a fixed cam below engages the lower end of the hinged arm to swing the saw across the path of the tubing.

A calibrated drawbar projecting from the carriage can be adjusted to give the required tube cut-off. As the tubing moves out from the forming operation it contacts a cup at the end of the drawbar at a predetermined point. The tube through the drawbar then pushes the saw carriage along its track and the saw is swung over to cut through the tube. When the sawn length of tube drops, pressure on the drawbar is released and an escape track in the cam withdraws the saw. The carriage assembly then returns to its original position ready to recommence the parting-off cycle when the oncoming tubing again contacts the drawbar cup.

A press tool which has been developed for the manufacture of the header plates is assembled in a die set and can be used either in a heavy fly-press, as illustrated, or on a power press if one is available. In this set (see Fig. 5) the punches are assembled in a holder in the base plate and the die is mounted on the head plate actuated by the press ram. The punches are locked in their plate by a simple form of anchor and they can quickly be introduced or removed in accordance with the arrangement and number of rows of tube holes it is required to punch in the header plates. An adjustable work guide frame built into the stripper plate of the tool can be set with reference to a scale to give the required width between the side of a header plate and the outer rows of tube holes. In the punching of the holes in the header plates, as in the case of the fin elements, the displaced material is bent out to form " boxes " in which the tubes are close sliding fits.

The cores are assembled in the conventional way in slotted jigs, as shown in Fig. 7. The standard jig made by the firm has an area of 36in by 30in, the larger dimension being that parallel with the tube axis so that radiator cores up to 36in high can be built. By progressively assembling and moving a core sideways across the width of the jig, cores of unlimited width can be assembled. A point of interest in the design of these jigs is the way in which the expensive machining normally entailed in slotting the plates of the upper and lower members has been eliminated. These members are now built up from 6in widths of light alloy extrusions in which the slots are ready formed on one side, and keyways formed on the other to permit their attachment to rigid back plates. Extrusions with slots for fin spacings from six to ten per inch are available, and by the use of sets of suitable extrusions a single jib can be adapted for assembling a range of cores.

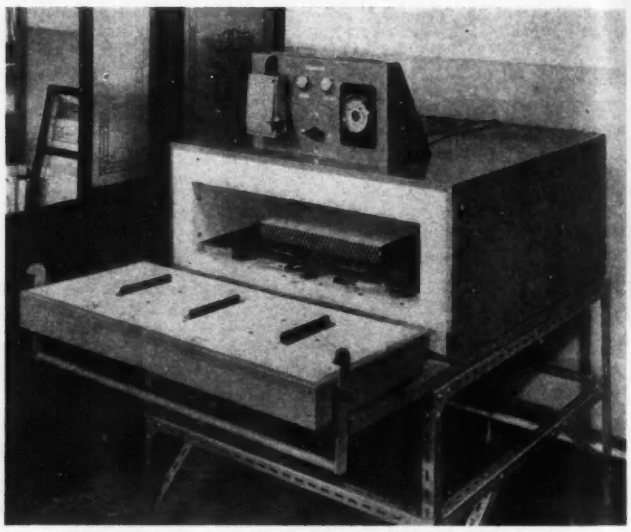


Fig. 6—Radiator Core Oven

The jig plates are mounted on trunnions or manipulator frames so that they can conveniently be swung into an upright position for loading the fin elements, and then swung back into a horizontal position for insertion of the tubes. Each jig is provided with a set of aligning bars and three tube swords adjustable for length are supplied. A stop on the swords can be set to give the required protrusion of the tube ends beyond the top fin of a core.

After the cores have been assembled they are dipped in a bath of flux and heated in an oven to the melting point of the solder to bind the tubes and fin elements intimately together.

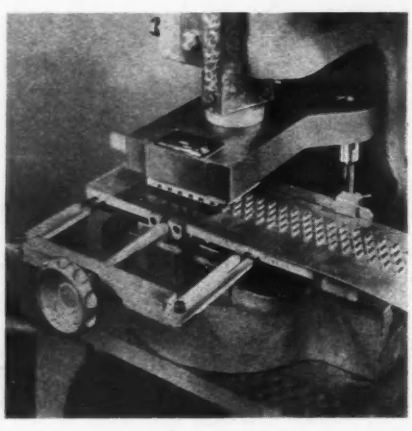


Fig. 5—Header Plate Punching Tool

At the same time, the fusing of the solder on the lock seam of the tubing gives a fluid-and-pressure-tight seal. In the heating operation close temperature control must be observed to ensure that, whilst the solder is heated till it just flows, the temperature is not sufficient to soften the copper alloy from which the fin elements are made.

The electrically heated soldering oven made by the firm for radiators is illustrated in Fig. 6, and it is stated to be capable of completing the soldering operation on an average radiator in five minutes. A thermostatic controller and indicator fitted to the oven maintains its temperature to within 5 per cent of preset values, and a low rated rotary switch gives a choice of three power loadings to cover the requirements of radiators from the smallest to the largest size made with the plant.

The oven has a sheet metal outer skin and an inner lining of insulating material which is

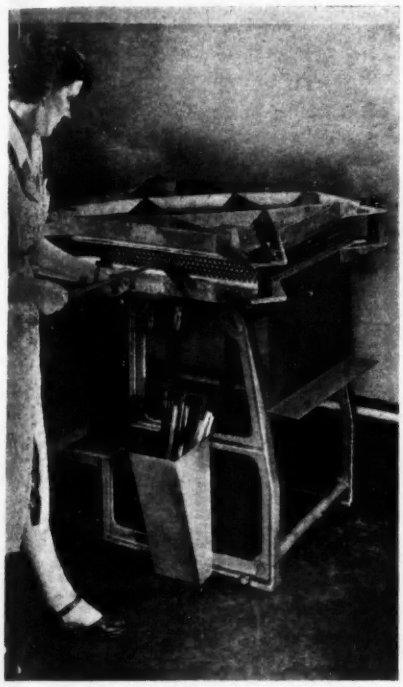


Fig. 7—Core Assembly Jig

resistant to the corrosive action of flux fumes. A 4in thickness of heat-resistant exfoliated vermiculite is interposed between the outer skin and the lining of the oven. The six sheathed radiant elements used to heat the oven are each rated at 1¼kW and together they are sufficient to bring it to the working temperature in about half an hour. When this working temperature has been reached the power input is automatically reduced to 2¼kW to maintain the temperature at the required level. The drop in the temperature which takes place when the oven is opened and a cold radiator is introduced is automatically compensated for by the switching on of additional elements, which remain effective till the working temperature is restored.

It will be seen from the illustration that the drop door of the oven provides a loading and unloading platform for the plate on which cores are supported in the oven.

Although the complete plant has been made available by J. W. Lawrence, Ltd., it is pointed out that under certain circumstances all the units may not be required. For instance, where tinned strip is available the pretinning unit of the tube machine is not necessary, and where a maker prefers to make and stock tubes in long lengths for cutting to size as required the cutting-off attachment can also be omitted. The number of assembly jigs can be selected in accordance with the required production of cores. As the slotted plates can be easily built up of extruded sections, one jig and sets of spare extrusions with different slot spacings might well satisfy the needs of a small plant.

Possibilities of a Cross-Channel Power Link Between the British and French Supply Systems*

By D. P. SAYERS, B.Sc.,† M. E. LABORDE, Ing.E.S.E.,‡ L. ès Sc.,‡ and F. J. LANE, O.B.E., M.Sc.§

Progress, up to the end of 1953, towards a cross-Channel power link between Great Britain and France is discussed. The first part of the paper outlines the history of the scheme and deals with general considerations; the second part reviews the technical problems of submarine power links and shows the progress made; the third part examines the operational aspects of transfer of energy and offers an assessment of the overall economics of the project.

THE pooling of spare generating plant and the optimum use of all sources of energy available are modern economic necessities.

In Britain and France extensive transmission systems have been developed to meet these requirements nationally, and the French system has been interconnected with those of neighbouring countries, thus securing the additional benefits of international connections.

The crossing of land frontiers presents no technical problem; interconnection between the French and British systems, however, means the crossing of a water frontier, and involves new technical problems which have been under investigation since 1950 by a Joint Committee representative of the two national authorities. Formal meetings have been held alternately in London and Paris, and particular aspects of the problem have been the subject of close and frequent informal discussion on both sides of the Channel. The earlier discussions culminated in an interim joint report presented to the two authorities in May, 1952. Programmes of investigation and practical development of cables, joints and accessories have been subsequently undertaken in both France and England.

The investigations described were, of course, not complete when the paper was written; the authors therefore cannot attempt any final assessment; nor would it be proper for them to anticipate the conclusions and decisions which will be made by the British Electricity Authority, Electricité de France and their respective Governments.

Choice of Voltage and Capacity of Interconnection

There are four system voltages to be considered, namely, 275kV and 132kV in England, and 225kV and 90kV in France.

It is clear that, whatever operating voltage is selected for the connection, suitable transformers will be required at one end or the other.

The selection of the appropriate cable transmission capacity and operating voltage depends on :—

(*a*) The maximum load which should be transmitted, having regard to the commercial and economic factors.
(*b*) The date at which service operation is required.
(*c*) The availability of capital.
(*d*) The possibility of changing from a.c. transmission to d.c. transmission within the foreseeable future.

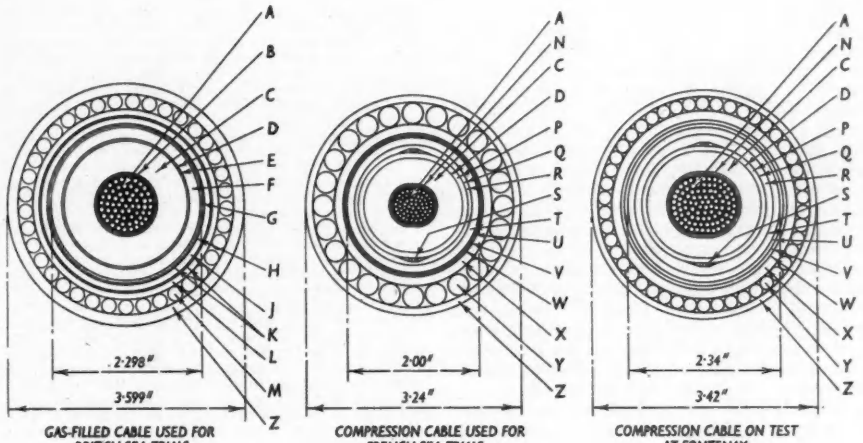
Consideration of these factors led to the preliminary conclusion that the initial capacity of interconnection should be not more than about 400MVA when operating at 275kV and not less than 100MVA at 132kV. A very broad comparison of these two proposals based on preliminary data provided by British cable manufacturers is given in Table I, and the subsequent detailed studies have been directed to the possibilities between these limits.

In addition to other factors, the charging current of the cable is an important consideration; it should be kept as low as possible, to minimise voltage rise effects and limitation of the circuit rating. Shunt reactors were considered necessary for the 275kV scheme, to limit the effects of the charging current on the system, but were not justified in the case of the 132kV scheme.

Possibilities of High-Voltage D.C Connection

The transmission of electric power on a large scale is at present carried out only by the use of high-voltage alternating current. Much effort and money has been devoted at various times in the past thirty years to the development of equipment for the production of high-voltage direct current, but so far no tangible success has been commercially demonstrated. At the time of preparing the paper the Swedish installation between the mainland and the island of Gotland is reported[1] to be well advanced, and the results may well have far-reaching effects on power transmission projects in various part of the world.

If the problem of conversion of a.c. power to high-voltage d.c. power, and vice versa, can be



GAS-FILLED CABLE USED FOR BRITISH SEA TRIALS.

A—Conductor.
B—Impregnated perforated and unperforated metallised paper screening.
C—Dielectric.
D—Copper tape dielectric screen.
E—Clearance under sheath.
F—E-alloy sheath.
G—One copper wire woven fabric tape.
H—Tin-bronze reinforcing tapes, tin coated, three layers.
J—Rubber.
K—Bituminized cotton tapes.
L—Jute bedding.
M—Aluminium alloy armour wires.
Z—Double jute serving.

COMPRESSION CABLE USED FOR FRENCH SEA TRIALS.

A—Conductor.
N—Conductor screen.
C—Dielectric.
D—Dielectric screen and copper tape.
P—Diaphragm lead sheath.
Q—Copper tapes.
R—Gas space.
S—Pilot wires.
T—Lead sheath.
U—Two copper tapes.
V—Longitudinal reinforcing copper tapes.
W—Radial reinforcing copper tapes.
X—Rubber sandwich protection.
Y—Steel armour wires.
Z—Bituminised jute serving.

COMPRESSION CABLE ON TEST AT FONTENAY.

A—Conductor.
N—Conductor screen.
C—Dielectric.
D—Dielectric screen and copper tape.
P—Diaphragm lead sheath.
Q—Copper tapes.
R—Gas space.
S—Pilot wires.
T—Lead sheath.
U—Two copper tapes.
V—Longitudinal reinforcing copper tapes.
W—Radial reinforcing copper tapes.
X—Rubber sandwich protection.
Y—Steel armour wires.
Z—Bituminised jute serving.

Fig. 1—Cross Sections of 132kV Cables Under Test

* Abstract. Institution of Electrical Engineers, London. April 1st.
† Midlands Electricity Board.
‡ Electricité de France.
§ British Electricity Authority.

solved technically and economically, the use of direct current for the cross-Channel connection would appear to have two important advantages.

Effect on Cable Design and Rating.—It is estimated by cable manufacturers that the insulation of a cable designed for an r.m.s. alternating voltage of 76kV to earth (132kV between phases) would be equally suitable for a direct voltage of 200kV to earth. When allowance is made for the difference in losses and permissible temperature limits, the maximum current is approximately the same in the two cases, so that, in very

TABLE I.—*Approximate Comparison of 100MVA and 400MVA Interconnection Schemes (Based on British Data)*

Interconnection capacity	100MVA	400MVA
Voltage	132kV	275kV
Length of cable	26 miles	26 miles
Cable particulars :		
Type	Single core	Single core
Conductor size	0·2 sq in	0·6 sq in
Overall diameter	3·25in	5·25in
Unit weight	25 lb/yard	70 lb/yard
Total weight per cable	500 tons	1400 tons
Losses at full load per three-phase circuit	7250kW	7500kW
Charging current per phase ...	180A	316A
Charging power per three-phase circuit	41MVA	150MVA
Estimated costs :		
Cost of four single-core cables and terminations	£2,900,000	£5,500,000
Cost of land connections :—		
England	£650,000	£1,400,000
France	£750,000	£4,600,000
Total cost of schemes...	£4,300,000	£11,500,000
Total cost per kilowatt of capacity	£43	£29

broad terms, the effective power transmitted per cable by direct current is approximately 2½ times that transmitted by alternating current.

Frequency Variation.—Subject to appropriate design of the conversion and inversion equipment, the d.c. system would permit of power exchange between two a.c. systems operating at different frequencies. On the other hand, the operation of a submarine cable carrying direct current appears to involve some practical difficulties which may be serious.

External Electromagnetic Effect.—The calculated magnetic field set up by direct current passing through a single-core submarine cable has been verified by practical experiments carried out during 1952 on a British cable to the Isle of Wight.

The external magnetic field set up by a two-core cable with "go" and "return" circuits is of course, substantially zero, but with a single-core cable the effect depends on the paths of the return current, which in turn depends on the method of earthing and the construction of the cable sheath and armouring. For a single cable with sea return, or with two single-core cables (if not laid very close together) the results are generally similar to a single-core cable with infinitely remote return ; with a sea return system the reduction in field due to the sea return current is insignificant, except close to the sea electrodes or for a very short cable.

If the results are applied to the practical example of a 200kV d.c. single-core cable laid across the Straits of Dover from north-west to south-east, a transmission of 100MW (500A) would cause the compass of a ship immediately over the cable lying at a depth of 25 fathoms to be deflected by about 4 deg.

Corrosion Effects.—If an uninsulated sheath return is used with a single-core cable, the current leaves the sheath within a fairly short distance of the terminals, because the sea, having relatively low resistance, carries almost all the current. Since there must be some voltage drop between the two ends of the cable, one end will become positive relative to the other and this positive end will suffer serious electrolytic corrosion. A possible remedy would be to apply cathodic protection, i.e. make the whole of the cable sheath cathodic by circulating current between it and the positive pole of a separate d.c. supply. Considerable difficulties might arise, however, particularly in relation to other cables and metallic substances in the neighbourhood.

Further detailed study and experiment is clearly needed to appreciate the full implications of these problems, but it is evident that the corrosion risk exists if direct current is applied to single-core cables with uninsulated sheaths. Adequately insulated sheaths appear to be impracticable, and the alternative of using a cable with two insulated cores would make the design of the cable more difficult and increase its cost.

Taking into account the immature state of development of conversion equipment and the other problems referred to, the Joint Committee came to the conclusion that a d.c. interconnection scheme was not immediately practicable, but that the possibility of a large-scale d.c. experimental transmission using a spare single-core cable merited serious consideration.

Interim Joint Report

A programme of development was recommended, covering the production, testing and installation of sample lengths of cables and joints, methods of surveying the route and of laying the cable and such associated problems as localisation of faults and repair technique. In view of the technical problems which would arise in the development of submarine cable for voltages higher than 132kV, the greater cost of a 400MW scheme—particularly of the associated land connections—and the relatively smaller financial benefits, the committee considered that further development should be confined to 132kV.

Cable Design Investigations

The earliest discussions in Britain, which were mainly directed to ascertaining the scale of the problem, were confined to two manufacturing firms having direct experience of the design and manufacture of high-voltage cables and of the laying of cables at sea. Subsequently the discussions were expanded to include all British manufacturers having experience of e.h.v. cables, and extensive information was provided on the various designs of cable suitable for operation at 132kV and 275kV and capable of dealing with load transfers of from 100MW to 400MW.

In France similar discussions proceeded between representatives of Electricité de France and the four French e.h.v. cable manufacturers.

Five types of cable were considered, namely :

(*a*) An oil-filled design which in the single-core cable would have a central duct in the conductor containing low-viscosity oil at a pressure of about 100 lb per square inch. Large tanks would be necessary at the terminal ends to cater for the varying thermal conditions, and special reserve capacity would probably be necessary to preserve the integrity of the cable in the event of an oil leak.

(*b*) Flat oil-filled three-core cables, similar to the type installed by Möllerhöj between Sweden and Denmark. It is an inherent characteristic of this design that feed tanks are not necessary to provide for thermal variations. Special reserve oil capacity might be necessary, however, to cover the possibility of oil leaks.

(*c*) Impregnated gas pressure cables, in which the paper dielectric is impregnated after application and gas at a pressure of some 200 lb per square inch is maintained in the interstices of the insulation from pressure vessels at the terminal ends. The impregnating process makes it necessary for manufactured lengths of cable to be individually tanked for drying and impregnation under controlled conditions, and the maximum length which would be handled at one time would therefore be of the order of 2000 yards. With a total length of 26 miles there appears to be some risk that compound migration might seal the gas passages at some point on the route ; this might be obviated by the use of a non-draining compound, but there has been no experience with this at 132kV.

(*d*) A pre-impregnated gas-filled cable, generally similar to (*c*), but employing insulating paper which has been dried and impregnated before cutting and applying to the cable. The method of impregnating the paper before application ensures an almost complete absence of free compound, and since passage of the cable through impregnation tanks is unnecessary, it becomes possible to manufacture it in much greater lengths. Special arrangements would be necessary for continuous lead sheathing and special production testing, but if these problems could be solved, manufacture of the complete length without joints would become practicable. This cable has a low charging current.

(*e*) A gas compression cable, in which the paper insulation is virtually as for solid type cables, but the conductor, insulation and surrounding lead sheath (diaphragm) are oval and enclosed in a second circular lead sheath, with gas under pressure between the two lead sheaths. This design, again, must pass through the impregnation tanks, with a consequent limitation on manufactured lengths. The presence of two lead sheaths tends to increase the weight and cost of manufacture, but these increases may be more or less offset by the possibility of increased working stress.

Single-core cables are preferable to three-core cables, because the dimensions are smaller and the joints far simpler.

As mentioned above, the Joint Committee came to the conclusion that the provision of a 275kV cable could not be justified initially, because of the high capital cost involved and the lack of service experience with cable at this voltage. Agreement was reached that a 132kV connection should be recommended, and this cleared the way for a selection of designs of cable on which experimental work should be carried out.

After careful consideration of all the factors involved it was finally agreed that works development tests and laboratory and sea trials should proceed on two types of cable, namely, the gas-filled pre-impregnated cable and the gas compression cable.

British Development Programme

Investigation Stages.—The British engineers considered that the gas-filled pre-impregnated cable would be the more suitable type, in view of the simplicity of the gas pressure system and the possibility of manufacturing the cable in long continuous lengths. Investigations were therefore confined to this type and proceeded in two stages, namely, trials chiefly concerned with works development of sample cable and accessories, and sea trials designed to demonstrate the suitability of the design to withstand the hazards of a laying operation from a cable ship.

Basic Specification.—The first necessity was to agree a basic specification for the pre-impregnated cable to be tested. The factors affecting the design are as follows :—

(*a*) The system voltage would be 132kV, with a variation of ±10 per cent.

(*b*) For a load of 100MW a copper section of approximately 0·20 square inch would be adequate for a cable laid on the bed of the Channel. Having regard, however, to the severe handling to which the cable could be subjected during the manufacturing and laying operations, it was felt desirable to increase the section beyond the necessary minimum in order to provide a reasonable margin of mechanical strength ; a section of 0·5 square inch was therefore selected. This increased size has the advantage of reducing the effective transmission losses ; moreover, it will permit greater freedom for transfers above 100MW, bearing in mind the impossibility of precise regulation of the transfer between two systems as large as those of the B.E.A. and E. de. F.

(*c*) The radial thickness of the paper insulation was determined as 0·5in on the basis of a maximum stress at the conductor of 90kV/cm and a screen stress of 41kV/cm. This latter value is important, since the insulation under the copper tape dielectric screen will be subjected to the most severe mechanical handling of the whole dielectric, and it is in this region also that the insulation is subjected to local heating associated with the sheathing process.

(*d*) The mechanical handling forces and the indeterminate stresses likely to be imposed on cable laid on the bed of the Channel indicate that the lead sheath should so far as possible be proof against vibration, and it was therefore agreed that alloy E (0·4 per cent tin, 0·2 per cent antimony) should be employed. Extrusion of this material would appear to present no particular problem and it will be rather more flexible than the alternative alloy B (0·85 per cent antimony). The fatigue limit of alloy E is 0·42 ton per square inch, compared with 0·18 ton per square inch for pure lead.

(*e*) The wall thickness of the lead sheath was fixed at 0·14in minimum, partly to ensure mechanical security during handling, but principally to ensure that if the cable were laid without internal pressure the sheath would not collapse under the external pressure of approximately 100 lb per square inch which may be experienced at the deepest part of the Channel.

(*f*) A diametric clearance of some 40–50 mils would be provided under the lead sheath, giving a gas space area of the order of 0·16 square inch, i.e. somewhat larger than would be used with land cable, in order to accelerate gas charging and assist gas leak location.

(*g*) Due notice was taken of experience with other types of submarine cable in determining the bedding, metallic reinforcement and overall serving.

(*h*) The external wire armouring would be subjected to the action of salt water and must resist corrosion. Since single-core cables were to be laid and previous experience in laying, locating and grappling had indicated that these must be separated by about 1000 yards, the resistance of the armour plus sheath and reinforcement should be kept as low as possible, in order to restrict the losses due to circulating currents. The sheath and armour losses, using galvanised steel wire armour, would amount to approximately 170 per cent of the conductor loss. Laboratory data and limited field experience indicated that the general mechanical and corrosion-resisting properties of certain aluminium alloy wires were at least equal to those of galvanised steel wire, and since their use would reduce the sheath and armour losses to approximately 61 per cent of the conductor loss, it was decided to use an aluminium alloy wire armour.

The increased risk of electrochemical corrosion between the aluminium alloy wires and the bronze reinforcing tapes if the interposed rubber layer were damaged was appreciated, but it was felt on balance that the construction was justified.

Works Development.—The works development programme then put in hand involved the manufacture of suitable lengths of cable for test purposes, the construction of a number of flexible and rigid joints and investigations, both theoretical and practical, into the suitability of certain of the materials.

While all the investigations related to the use

of aluminium alloy armouring confirmed its suitability as a corrosion-resistant material, tests carried out in the laboratories of the works and the B.E.A. indicated that the abrasion effects when immersed in salt water were some six times greater than the corresponding effect on steel. In the short time available for development prior to the sea trials it was not possible to give full attention to the rigid or "sea-going" joint, and the joints developed at this stage were based on the conventional box pattern.

For testing purposes the cables and joints were treated as though they were entirely new designs, but in addition to normal type tests special tests were included in the programme as follows :—

(*a*) Behaviour of the cable and joints when gas filled at atmospheric pressure, but subjected to external pressure corresponding to deep laying.
(*b*) Power factor stability and impulse tests on flexible and rigid joints.
(*c*) Bending tests on flexible joints.
(*d*) Lowering test on rigid joints.
(*e*) Coiling-down test.

It was found possible to produce a flexible joint having the same external diameter as that of the main cable by butt brazing the individual strands and using a lead burning technique to joint the outer lead sleeve of the joint to the lead sheath of the main cable. With such a joint it was found possible to achieve an impulse-withstand level of about 550kV, as compared with the level of 640kV normally specified for the 132kV system, but when account was taken of the modifying effect of the cable on surges entering from the system, this was considered satisfactory.

As soon as it appeared that suitable equipment for an extended test could be provided, arrangements were put in hand for carrying out the sea trial off the coast of Kent, more or less in a position corresponding to that of the expected English termination in the final project.

In parallel with the development work in Britain, two of the French manufacturers had proceeded with some development work on pre-impregnated paper cable. A suitable length of this cable using impregnated paper supplied from Britain was produced by one of them and included in the British sea trials.

The principal characteristics of the British cable selected for the sea trial are compared in Table II with those of the French cables tested at the works and at the central testing station at Fontenay, while Fig. 1 shows comparative cross sections of the British pre-impregnated gas-filled cable and the French external compression cables.

TABLE II.—*Principal Characteristics of 132kV Cables for the British Sea Trial and the French Tests at the Works and at Fontenay*

Cable	Rating	Conductor area	Maximum stress	Thickness of insulation	Armouring	Overall diameter	Weight	Losses per 26-mile three-phase circuit at 100MW				Charging current/phase
								Conductor	Dielectric	Sheath	Total	
	MVA	sq in	kV/cm	in		in	lb/yd	kW	kW	kW	kW	A
British.												
Pre-impregnated gas-filled	200	0·5	90	0·515	0·232 in aluminium alloy wires	3·6	136	1410	141	860	2411	208
French.												
Pre-impregnated gas-filled	200	0·62	85	0·51	0·2–	3·54	51	1400	230	1300	2930	245
External compression ...	200	0·59	117·5	0·35	0·3in	3·40	54	1540	250	1260	3050	365
Pre-impregnated gas-filled	100	0·24	85	0·63	steel	3·30	42	4370	140	3240	7750	155
External compression ...	100	0·19	125	0·40	wires	3·15	44	5000	150	3100	8250	215

Sea Trial.—The object of the sea trial was primarily to determine the effect on the cable and associated joints of the severe mechanical conditions associated with laying from a cable ship, and to obtain experience in the making and laying of joints at sea.

Arrangements were made with the British Post Office to hire the cable ship "Alert" (1460 tons gross). Two lengths of British cable about 880 yards long were prepared, each with a factory-made flexible joint at the mid-point. In addition, the French manufacturer prepared a length of about 230 yards of similar cable, but without a flexible joint.

The broad sequence of the programme was as follows :—

(*a*) To coil in the tanks of the "Alert" the three lengths of cable.
(*b*) To stand off shore with the cable ship and to float one end of a British length to a sealing end testing position on the beach well above high water.
(*c*) To connect by a rigid joint the first of the British cables to the second of the British cables, this operation to be done at sea.
(*d*) To run out and lay the second length of the British cable in a straight line from the landing point.
(*e*) To lay the French cable, which had already been provided with a stop end joint for its outer end.
(*f*) To join the second length of the British cable to the French cable by means of a rigid joint made at sea, thus simulating a closing repair joint.

The resulting layout is illustrated in Fig. 2. The actual trial was made between July 21 and September 9, 1953. Initially the weather was very favourable, and the arrangements for landing the terminal end proceeded without any very serious difficulty, although minor problems arose resulting from the drift of the tide and the presence of rocks close inshore.

When the first rigid joint was being made, however, the weather worsened considerably, and after about forty hours became so bad that further work was impossible. The cable was therefore cut, sealed off and buoyed, and the ship returned to harbour. While the ship was in harbour the opportunity was taken to complete the stop-end joint on the French length of cable.

The programme was now modified and the cable ship dropped the stop-end joint in the sea, laying the French cable towards the shore, finishing in a position where it could be buoyed ready for connection to the second British length.

The seaward end of the first cable was then picked up and jointing with the second length was completed in thirty-four hours in good weather. This joint was laid and the second British cable was laid out to the termination of the French length. The joint between the British and French lengths was completed in twenty-six hours. The whole of this operation was completed without pressurising the cable, and this process was then commenced. Subsequently the cable was subjected to high-voltage d.c. tests.

During the course of the work attempts to use underwater television to view the cable and joints *in situ* were not successful, largely owing to illumination and focusing difficulties.

Lessons of the Trial.—The cable suffered damage in four places during the test, but it would be invidious to examine the incidents in detail here. Following the tests and successful energising at 300–400kV d.c. the cable and joints were recovered and taken back to works for examination. Important lessons to be learned from the sea trial and other experimental work are as follows :—

(*a*) The length and direction of lay of the armouring, the size of wire and the space factor have an important bearing on the way in which the cable coils down into the tanks and on the possibility of kinking when manœuvred on deck for jointing operations. Although there is much experience with telegraph cables available in this respect, the heavier structure of the power cable introduces new problems.
(*b*) On the occasion of any damage to the rubber layer between the armouring wires and the reinforcing tapes, sea water may penetrate for appreciable distances unless close and continuous contact can be maintained between the rubber and the tapes.
(*c*) The mechanical strength of the reinforcing tapes needs to be determined, not only with regard to the pressure within the cable, but also to the severe treatment when handling and lashing the cable.
(*d*) Rough handling of the cable near a flexible joint in the vicinity of a cut or free cable end will almost certainly cause longitudinal displacement between the conductor and the sheath, with resultant damage to the hand-applied dielectric, unless the conductor, sheath and armour are mechanically anchored together at the free end. As a consequence it will be important to provide suitable external identification of the position of a flexible joint, so that it can be cut out if the cable is grappled within a prescribed distance.
(*e*) Joints to be made at sea must be simplified as much as possible, so as to minimise the time required for making. A completion time of eight hours seems possible but will necessitate radical changes from the conventional designs. The severe handling, particularly during the jointing and laying operations, will necessitate a construction limiting the amount of conductor movement relative to the sheath as well as positive means for restricting the bending radius at the entrance to the joint.
(*f*) Shore end conditions must be carefully studied and may necessitate special measures such as a properly constructed channel through the rocks and the provision of "rock armour" on the cable, to minimise damage during laying and in service.
(*g*) For the final project the capacity and equipment of the cable laying ship will need very critical examination. For the actual laying operation ample storage space is required, and if joints have to be made ample deck space must be provided to minimise the risk of sharp bends. For routine repairs a smaller vessel may be adequate if properly equipped.
(*h*) For a successful and expeditious installation a high degree of co-ordination is essential between the working parties on land, the ship's captain and crew and the engineers and workmen on board.

FRENCH DEVELOPMENT PROGRAMME

The main part of the programme was finalised and work started in March, 1953. This is a good deal later than the date of the beginning of the development work in Great Britain and explains why the French research and tests are not so advanced.

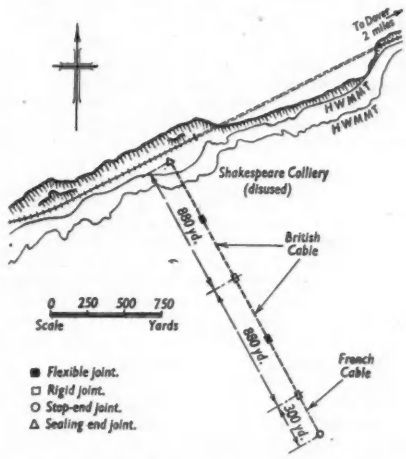


Fig. 2—Cable Arrangements for the British Sea Trials

Cables to be Tested.—The cables tested are of the gas-filled pre-impregnated type and the external gas compression type. The latter was included because of its higher working stress and consequential reduced insulation. Since this type is not easily manufactured in long lengths it is particularly important to develop suitable flexible joints.

The specifications are based on the following factors :—

(*a*) Designs of the two types as used on the British 132kV system.
(*b*) Experience acquired at the Fontenay Research Centre from tests during the last four years on 225kV gas cables.[3]
(*c*) Results of general French cable works tests during the last few years.
(*d*) Direct technical liaison between one French and one British manufacturer of the gas-filled cable.

The individual test lengths of both types were manufactured to the same basic specifications, but include variation in detail.

In order to obtain the maximum benefit from the preliminary programme it was decided to test cables suitable for transmitting 100MW, as suggested by the Joint Committee, and also cables with a heavier cross section (see Fig. 1), approaching the economic optimum (approximately 200MVA). The object of including the right-hand cable, Fig. 1, was to investigate the influence of the increased diameter and weight on the manufacturing and laying of the cables and on their reliability.

The principal characteristics of the four cables to be tested in the manufacturers' laboratories and in the Fontenay Research Centre are shown in Table II, where they are compared with the British cable used for the sea trial ; a sample of the latter cable is also to be included in the dielectric test programme.

For the French sea trials it was essential that

the test lengths forming the composite installation should be designed to similar basic specifications, in order to avoid difficult problems in connection with joints, fault location, &c. The British sea trials were to be made with pre-impregnated cables, and it was therefore decided that French sea trials would be confined to external compression cables. The four French cable manufacturers are each to supply a length of this cable generally in accordance with the specification detailed in the bottom line of Table II. A similar cable manufactured in Great Britain can be included in this test at a later date.

Joint Specifications.—It was decided to use two types of joint for each type of cable, namely, a flexible joint which could be manufactured in the works to permit the complete cable to be laid in one operation whatever the lengths manufactured, and a rigid joint suitable for repairs at sea. For these two types no specification was laid down in advance, since this was to be settled after the tests in the works, in the Fontenay Research Centre and at sea.

Outline of the Test Programmes.—The programme may be divided into three groups, namely, individual works tests, comparative tests at the Fontenay Research Centre and sea trials. The first two groups apply equally to the two types of cable selected and the third only to external gas compression cable. The detailed programme for each of these groups is given below, together with brief details on the progress achieved.

Works Tests.—In practice, the tests are made on short samples with a view to (*a*) determining the insulation withstand level under 50 c/s impulse and under d.c. conditions, and giving some indication of the life curves for the cables and their accessories ; and (*b*) checking the ability of the cables and their joints to withstand the estimated mechanical stresses to which they may be subject during manufacture, transport, laying and operation.

The tests were commenced during 1953 and have shown particularly that for the compression type cable breakdown stresses of about 400kV/cm can be obtained in laboratory tests, and that flexible joints can be designed for both types of cable with a dielectric safety factor practically equal to that of the cables themselves.

Tests at Fontenay.—The tests at Fontenay Research Centre were designed primarily to supplement the works tests, using larger and more powerful testing plant, and to obtain directly comparable results by testing the various sample cables and joints under identical conditions. All cable samples tested electrically were equipped with 225kV sealing ends, since 132kV designs were thought to be sufficiently well established to need no special tests.

The tests are divided into three groups :—

(*a*) Tests of performance when directly connected to the 225kV system.
(*b*) Dielectric tests on samples, using laboratory machines and apparatus.
(*c*) Mechanical tests.

They were started in the autumn of 1953, so that it is still too early to draw conclusions, but they are sufficiently interesting and important to be worth listing below. Group (*a*) included thermal stability and dielectric tests.

For the former, a length of cable laid in a loop is connected to the 225kV system. The loop can be opened or closed as required, and " phantom " load tests can be made by means of a transformer placed around the cable.

As a result of laboratory and field tests on land cables in France it has been concluded that a satisfactory design should withstand without ageing an electric stress equal to about 1·5 times the normal working stress. For a submarine cable it seems reasonable that this safety margin should be increased, in order to reduce the possibility of breakdown and to avoid so far as possible the cost and difficulty of repairs. By connecting the cable to one phase of the 225kV system the test stress is about 1·7 times that resulting from 132kV operation. The heating cycles will be eight hours per day, with the currents in the conductor and the sheath being made approximately equal to those under service conditions.[2] A 130-yard length of each of the four cables of French manufacture and a similar length of British pre-impregnated gas pressure cable will be tested in this manner.

Flexible joints should fulfil the same requirements as the cable, and therefore sample joints are to be included either in the 130-yard lengths or in additional 20-yard lengths. The latter can easily be disconnected in case of failure without interrupting the test on the other lengths.

Further 20-yard lengths of cable, each with a joint midway, are to be tested at about three times the nominal stress by connecting the conductors to one 225kV phase and the lead sheaths to another phase, with the whole cables supported on insulated platforms. It is intended to continue these tests until breakdown occurs, and to repeat them on identical samples to reduce error due to dispersion. These tests will be applied to the gas compression cables, but not to the gas-filled cables.

Reactances have been installed in series with the connections to the Fontenay busbars to limit the short-circuit current if a fault occurs. Resistors in the individual circuits connected at the line voltage will reduce the possibility of a fault on one sample affecting adjacent samples under test.

In group (*b*) laboratory tests will be made on other short samples, some of which will include a flexible joint, and will consist of conventional 50 c/s breakdown tests designed to provide information on life characteristics supplementary to that given by the works tests. The same generators will be used throughout, to provide comparable results. Impulse tests will also be made to determine the withstand level of the various designs.

In group (*c*) the mechanical tests are planned to reproduce as nearly as possible the stresses to which the cables may be subjected during handling, laying and grappling. Tension effects during laying may be fairly limited normally, but momentarily may reach values of the order of 6–8 tons weight. Grappling and lifting the cable may set up severe tensile stress conditions. Torsional stresses are imposed during coiling and may be present due to the reaction of the armour wires when subjected to pulling tension. Bending usually takes place at the winch drums and over the sheaves through which the cable leaves the ship. The basic tests devised are a tension-torsion test and a drum-coiling test. The cable will be capped at each end, and armouring wires will be used to form pulling eyes. Each cable will be kept under gas pressure at 225 lb per square inch.

For the tension-torsion test a 10-yard cable sample with one end fixed will be subjected to a progressively increasing tension up to 5 tons weight. At the pulling end it will be possible to measure the angle of distortion as a function of the load, and the torques necessary to counteract the distortion. A second test will be taken up to 10 tons, but distortion will be prevented.

In the drum coiling test the cable will be subjected to a fixed pulling load and distortion will not be restricted. A special drum has been devised with a horizontal axis and with three available diameters, 9·2ft, 7·9ft and 6·6ft. Each test cable sample, about 33 yards long and including a flexible joint about one-third of the distance from one end, will be wound once around the drum at the selected diameter and will be held in tension by a force of about 5 tons weight. An auxiliary pulling system will give the cable a reciprocating movement, so that each part is bent round the drum and then returned to the straight-line position. Each sample will be tested on each diameter, with five reciprocations on the large one, five on the medium one, and not more than five on the small one. After the tests the condition of the component parts of the cable will be checked—a pressure test on the lead sheath, an insulation test on the rubber sandwich between the armour and the reinforcing tapes after immersion in water, and a d.c. test on the insulation. Stripping and further detail investigations will follow, depending on the results obtained on the main tests.

Sea Trials.—The trial programme has been arranged in two stages : in the first, the objective is to obtain information on the behaviour of the compression cable and its accessories during laying operations, and so determine what modification to the specification of the test cable and laying plant may be needed ; in the second, additional lengths of cable will be laid and jointed at sea, in order to study the jointing and repair procedure, the locating of the cable, the locating of faults and the rate of water penetration under fault conditions.

The site chosen for the sea trial is the end of the Carnot jetty at Boulogne-sur-Mer. This consists of a reinforced concrete pierhead on which one end of the cable can be terminated and accommodation arranged for the testing equipment and personnel. The pierhead is surrounded by water exceeding 32ft in depth at the lowest tide, so that practically the whole of the comparatively short test cable will be submerged in fairly deep water.

One of the cables used for these trials is shown in Fig. 1 (centre). The cables will comply generally with the particulars given in the bottom line of Table II, but with some variations in detail according to the different manufacturers.

Each of the four manufacturers participating in the tests provided a test length of approximately 120 yards. These were jointed in the factory with three flexible joints, and the whole length was then armoured in one operation ; one end was terminated in a stop-end joint, and the complete assembly was tested at 400kV d.c. before being transported by rail to Boulogne quayside and there coiled down on the flat deck of a barge.

On December 15, 1953, the barge was taken out to the pierhead and the cable was laid out from the pier on a nearly straight course. After the end on the pier had been fitted with a 225kV sealing end the installation was successfully tested at 400kV d.c.

At the time of writing the next tests envisaged include further high-voltage tests and then low-voltage heating cycles to check the thermal characteristics of the cable.

Two additional lengths of cable to the same specification, each approximately 540 yards long and including one flexible joint, will be jointed together beforehand with a flexible joint and then laid at sea as a continuation of the test length laid in December, 1953 ; this will involve the making of the closing joint at sea. After high-voltage tests have been accomplished an artificial gas leak will be made in the cable by a diver and the accuracy of various methods of locating the fault will be investigated while the maintenance of pressure and the penetration of sea water are studied. Subsequently it is intended to raise the cable at the faulty point and repair it at sea. After final high-voltage tests up to 600kV the cable and joints will be recovered and returned to the laboratory for detailed examination and test.

Operational Considerations—Parallel Operation

If the full value of the interconnection is to be obtained the two systems must operate continuously in parallel. The capacity of the link contemplated is very small indeed in relation to the demands on the two systems, and very accurate control will be essential. It is therefore necessary to be able to predict the fluctuations likely to occur in practice and the degree of control needed.

Frequency Tests.—The problem of frequency has been studied by a series of large-scale tests carried out on the B.E.A. and E. de F. systems with the object of assessing the national power/frequency relationship for various conditions of plant and load and correlating the fluctuations of power transfer between two systems when interconnected with the fluctuations in the difference between their frequencies when disconnected. The first tests were carried out on the E. de F. system in December, 1952, and those on the B.E.A. system in June, 1953.

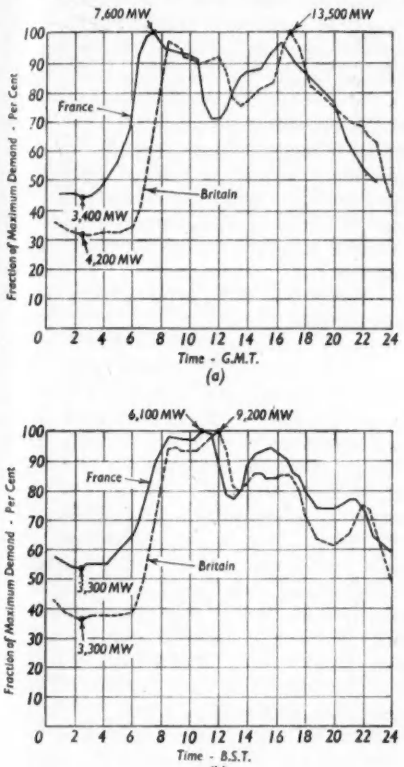
The tests were broadly of three types :—

(*a*) With two halves of the system connected by a single line carrying a certain transfer the line was tripped, and from high-speed recordings of frequency and power transfer the power/frequency relationships for each of the two halves were calculated.
(*b*) With the system interconnected a substantial block of generating plant was switched out, thus enabling a direct assessment of the national power/frequency relationship to be made.
(*c*) With the same system arrangement as in (*a*) the two halves of the country were operated interconnected for about fifteen minutes, each half trying to maintain the frequency at exactly 50 c/s and zero transfer on the interconnector. The interconnection was then opened and for a similar period each half of the country again tried to maintain this frequency.

Results of Tests.—Full discussion of the method

of interpreting these tests is beyond the scope of the paper, but the results indicated that in Britain a change in frequency of 0·1 c/s corresponds to over- or under-generation of 300MW ; in France the corresponding figure is 100MW. The E. de F. system is already provided with a measure of automatic frequency control, which is being extended. The B.E.A. system is not automatically controlled, and further investigations are in progress to determine the technical and economic effects of installing automatic control equipment.

On the information at present available the fine degree of control needed for the satisfactory operation of the proposed link could be obained only by the use of automatic equipment. This problem is being further investigated by establishing a direct communication circuit between London and Paris and recording for a period the differences between the two system frequencies. This information, together with that already



(*a*) For December 10, 1952.
(*b*) For June 18, 1952.

Fig. 3—Daily Load Curves as Percentage of Maximum Demands

obtained, will enable an assessment to be made of the uncontrollable power fluctuation which would occur on a cross-Channel cable.

Economic Aspects

Reference was made to the different characteristics of the French and British systems. The economies to be expected from interconnection consist in :

(*a*) Savings in capital investment on generating plant due to reduction in the total amount required in the two countries by reason of the pooling of spare plant and diversity in maximum demand.

(*b*) Savings in operating expenses due to the transfer of energy from one country to another when the costs of production are different.

These savings have been assessed by detailed discussion between the operating staffs. Since August, 1951, national daily load curves have been exchanged between the two countries, and each country has quoted to the other incremental and decremental costs of generation hour by hour.

Diversity of Demand.—During the winter diversity occurs between the demands on any given day, largely because the French national time is then one hour in advance of Greenwich mean time. Moreover, in December, which is now the most critical month in Britain, the French daily maximum demand occurs at 8.30 a.m. (7.30 a.m., G.M.T.), while in Britain the daily maximum demand occurs at 5 p.m. G.M.T. The diversity during a typical winter's day is illustrated in Fig. 3 (*a*), which shows the half-hourly demands for France and Britain plotted on a percentage demand basis for easy comparison ; the demand on a typical summer's day is shown in Fig. 3 (*b*).

Day-to-day diversity also occurs, mainly owing to differing weather conditions in the two countries and the fact that the biggest demand risk occurs on Wednesday in France and on Monday in Britain. In Fig. 4 the daily maximum demands for the two countries are plotted for November–February, 1952–53, inclusive, again on a percentage basis. It will be seen that the British maximum demand occurred on December 15, 1952, and the French on January 9, 1953.

Studies of the past four years have revealed the following winter diversities (the differences between the highest simultaneous maximum demand and the aggregate of the highest individual demands) :—

	MW
1949–50	548
1950–51	410
1951–52	470
1952–53	600

Savings in Capital Investment.—On the basis of experience over recent years, the Joint Committee considered that a minimum winter diversity of 300MW could be relied upon. If a 100MW interconnector were installed, each country could rely on receiving, at the time of its maximum demand, 100MW from the other country, thus

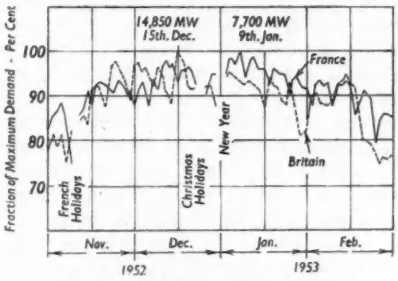


Fig. 4—Daily Maximum Demands

making possible a reduction in the generating plant capacity otherwise necessary in each. The combined saving (at 1951 price levels) was estimated roughly at about £10,000,000, against which the capital cost of the interconnection was estimated at £4,300,000, thus showing a net saving of the order of £5,700,000. For the 400MW scheme the net saving was estimated at only £3,500,000, because no diversity greater than 300MW could be assumed ; if in practice a greater diversity were realised, a correspondingly larger capital saving could be achieved.

Economic Energy Transfers.—Three types of exchange have been investigated :—

(*a*) *Utilisation of Spill Energy from French Hydro-Electric Plant.*—France would export to Britain the hydro-electric spill energy which she is unable to absorb herself and which would otherwise be wasted. This would take the place of an equivalent amount of thermal generation in Britain.

(*b*) *Hydro-Electric-Thermal Exchanges.*—When the French hydro-electric stations have surplus power available, France would export hydro-electric energy to Britain at the time of the British daily peak period, replacing generation by stations in Britain having the highest fuel cost per unit at that time. Britain would return this energy, with an allowance for transmission losses, during off-peak periods, on the same day, and simultaneously the production of hydro-electric energy from the French reservoir stations would be correspondingly reduced, thus preserving the French water storage position.

(*c*) *Thermal-Thermal Exchanges.*—Where the cable would not be fully utilised by operations (*a*) and (*b*), the costs of production of thermal energy in the two countries would be compared, taking into account transmission losses and economic exchanges made.

It would not be possible to operate under conditions (*a*), (*b*) and (*c*) at the same time, but on the assumption of an optimum combination throughout the year, the general order of the annual savings to be shared between the two authorities, with transfers limited to 100MW, has been estimated as follows :—

Under operation (*a*)	£100,000
Under operation (*b*)	£150,000
Under operation (*c*)	£350,000
Total annual saving	£600,000

The full realisation of these savings would depend on ideal operation of the interconnection, assume no monetary exchange difficulties and a rate of exchange of 980f. to the pound. In practice it would not be possible to achieve ideal operation, so that the actual savings would be rather less than the figures shown.

Overall Assessment

The investigations described in the paper indicate the order of savings which might be made if the British and French systems were linked by a cross-Channel cable. The realisation of these savings would depend on the cable being available for service at all times. From the work already done there is little doubt that suitable cables can be manufactured and installed ; the only doubt arising is the risk of breakdown after installation and the practicability of effecting quick and satisfactory repairs. The provision of a fourth single-core cable as a spare, with facilities to permit switching in place of any of the three cables normally in use, would clearly ensure a higher availability of the circuit. The other fundamental problem on which doubt exists is whether the two systems can operate continuously in parallel through an interconnection of the size under consideration. The prudent course would appear to be an initial installation of the minimum capacity consistent with reliable operation but planned with a view to increasing the capacity when practical service experience has proved its worth.

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Durban Oil Refinery

THE £7,000,000 oil refinery of the Standard-Vacuum Refining Company of S.A. (Pty.), Ltd., at Wentworth, on Durban Bluff, went into full production of petrol and allied products during the first week of January this year. In 1951, when the work began, the company set January 1, 1954, as the deadline for completion. The refinery will ultimately process 200 million gallons of crude oil a year from which will be produced 80,000,000 gallons of petrol, which is more than 20 per cent of South Africa's total petrol requirements. Since the beginning of September last, nine young South African engineers have been in course of training for, and gaining experience in, the control of the new plant. Five years ago the site of the refinery was rank bush and weeds. During peak construction times as many as 1000 men were employed on the site. Heavy equipment used in building the refinery was imported so as to prevent a drain on South African steel supplies. Some of the refinery towers are 135ft high. As well as producing over 20 per cent of the petrol at present used in the Union, the plant will also produce 33 per cent of the illuminating paraffin, 20 per cent of automotive diesel fuel requirements, and 6 per cent of the power paraffin. Some 300 Europeans are working in the refinery area, apart from a substantial native labour force. As soon as the refinery is in full production, South Africa will have a degree of independence in oil supplies which it has never before experienced. The refinery need not be dependent for all supplies of crude oil on one source, but can draw on the numerous sources available in the Middle East, the Dutch East Indies and in other areas, particularly South America. A possible and important development in the future may be the laying of a pipeline from the refinery to the new Reunion Airport to provide a central refuelling base for jet aircraft in Southern Africa.

SCHOLARSHIP FOR AUTOMOBILE STUDY.—C. C. Wakefield and Co., Ltd., has supported the motor industry's four-year residential diploma course, sponsored by the Institute of the Motor Industry, by donating a scholarship, to be named " The Castrol Scholarship," of £150 per annum tenable for four years at the Loughborough College of Technology.

THE ENGINEER

Vol. 197 APRIL 2, 1954 No. 5123

LEADING ARTICLES—

Scientists and Technologists in Industry 498
Modern Missiles and their Guidance 498

ARTICLES—

Australian Built "Sabre" Jet Fighter 503
Cement Factory at Bamburi, Kenya. (Illus.)... 508
Conference on Hydraulic Mechanisms 481
Durban Oil Refinery 497
Economic Survey, 1954 500
Emergency Pneumatic Actuators. (Illus.) ... 511
Extensions at Battersea Polytechnic 481
First Transatlantic Telephone Cable. (Illus.)... 505
Freight Charges and Transport Efficiency ... 481
Freight Marshalling Yard at Stratford, London 509
French Locomotive Experiences. No. IV. (Illus.) 484
Gas and the Aircraft Industry 510
Heat Exchangers for Internal Combustion Engines 510
Institute of British Foundrymen 481
International Railway Congress... 510
Machining of Compressor Rotor Discs. (Illus.) 507
Pipe Flange Welding Jig. (Illus.) 511
Progress of the Tennessee Valley Authority. (Illus.) 501
Possibilities of a Cross-Channel Power Link Between the British and French Supply Systems. (Illus.) 493
Radiator Core Making Plant. (Illus.) 491
Rayon Project on Natal South Coast 506
Recording Signals from Resistance Strain Gauges. No. III. (Illus.)... 482
Research in the Coal Industry 481
Research on Reclamation from the Wash ... 481
Research Station for Short Circuit Testing of Switchgear. (Illus.) 488
Seam Welder Using Continuous Wire Electrode. (Illus.) 506
Smoke Reduction in the City of London... ... 481
Symposium on Gas Absorption... 487
Two Chucking Automatics. (Illus.) 511
Two-Stage Fuel Filter. (Illus.)... 510
V.H.F./U.H.F. Transmitter for B.B.C. Experimental Work. (Illus.) 504

LITERATURE 499
Books Received 500
Short Notices 500

NEWS AND NOTES—

Books of Reference 502
British Patent Specifications. (Illus.) 515
British Standards Institution 516
Catalogues 516
Contracts 516
Forthcoming Engagements... 516
Indian Engineering News 512
Industrial and Labour Notes 513
Launches and Trial Trips 516
Notes and Memoranda 514
Personal and Business... 514
Technical Reports 512

SCIENTISTS AND TECHNOLOGISTS IN INDUSTRY

In our last issue we referred to the publication of the report for the year 1952–53 of the Department of Scientific and Industrial Research. At about the same time there was published by the Manchester University Press a book entitled *Industry and Science*. The coincidence is intriguing. For whilst the report describes the work being done by the various research bodies of the Department and by the industrial research associations aided by it, the book contains a study of the use made by industry of scientists and technologists and of the discoveries of research. The Advisory Council for the Department has, of course, no doubts whatever about the value of research. Its only regret is that difficulties were created during the year under review owing to the exiguity of the Department's financial resources; and it welcomes the recent decision of the Government to expand those resources and to permit the development of a plan for substantial growth. The book, by contrast, indicates that industrial enthusiasm for conducting research, making use of research results and applying scientific methods varies very widely. It records the results of a survey carried out in the Manchester area by three investigators for the Manchester Joint Research Council. The references in the book to the attitude of industry to research associations are, of course, of particular relevance in this context; and it is rather disturbing to observe the conclusion that "a large number of members of research associations show little realisation of the full extent of the scientific help and other services which their particular association can afford." Many of them seem to regard these associations much more in the light of "trouble-shooters" and "information bureaux" than as "establishments mainly devoted to research and development activities likely to be of value to the industry as a whole." But there is much else in the book that is enlightening, intriguing and interesting.

Obviously, however good the work of D.S.I.R. establishments, research associations, universities and other bodies, it cannot be applied unless there is an appreciation within industry of its value; and that appreciation can only be expected if there are an adequate number of men trained in science and technology in industry. The picture revealed by the book is not entirely encouraging. Of the sample of firms in several industries studied only one-half employed at least one qualified scientist or technologist. But those firms represented as much as 84 per cent of the total employed personnel covered by the investigation. Over 80 per cent of all the scientists and technologists were concentrated in just under one-third of the firms; and one-third of the firms visited employed either no scientists or technologists at all or very few. The investigators do not seem to regard that situation as unsatisfactory on the grounds that about one-third of industry "does not really require much from science," and that another third "requires mainly competent application of established principles." But they do regard nearly half the firms needing scientifically trained men as understaffed. To what extent are those opinions really justified? Certainly there must be some firms, such, for example as those doing subcontracting work which may expect their principals to do any necessary researches into design and productive methods. Others, it is suggested, can depend upon the suppliers of raw materials for information about advances. Such firms may be able to get along profitably without internal technological advice. Again, it is obvious that in newer industries making use of more recent scientific discoveries there may be more scope for research and development than in older established industries. But those arguments do not seem to us to ring wholly and completely true. They may express some truth but not the whole truth. For even if there is little or no scope for research and development (are there really any firms in which there is no scope for development?) a scientifically trained mind can make valuable contributions on the actual production side. The book, indeed, refers to a lack of appreciation amongst some firms upon that point; and the investigators themselves are by no means convinced of the validity of some of the reasons given by a few firms for not supporting their research associations.

The meaning of one fact revealed by the investigation needs to be treated with reserve. Only 9 per cent of the firms approached considered that they would make use of a national sponsored research institute if its services were available. But that low volume does not accord well with the opinion of the investigators that less use than might be was made of association facilities because of a fear that the trend of a firm's researches might thereby be inadvertently revealed to competitors. In our view it seems very possible that were there more experience of sponsored research in this country a much higher percentage of firms might become interested. Another revealing point found by the investigators was that despite "the wealth of knowledge and experience to be tapped merely for the asking," firms still experienced trouble in finding where to go for answers to their problems. There is "a very real need of some means of informing those in industry where the most appropriate sources of knowledge can be found." One peculiarly human factor was noted. "Opinion is more likely to be influenced by the arduous process of individual conversation than by any other form of activity." In fact what Tom, Dick and Harry have to say at the club, at a conference, or in the train, is more effective in bringing about changes than occasional public pronouncements by great men. The point is worth emphasis. If science is to be more effectively used in industry, if productivity is to be raised, if in short the industrial climate is to be altered then the preaching must be carried down as near as possible to the individual level. That conclusion ties up with another to be drawn from the book. The influence upon the policies of firms of individual personalities seems to be very marked. Those firms with trained technologists or scientists on their Boards proved also to be those most actively interested in research and development and the employment of trained personnel.

MODERN MISSILES AND THEIR GUIDANCE

As the contrast between what are known as conventional weapons and those which certainly are not grows more and more marked, the problems presented to the governments of the day increase in complexity. Each country realises that its current form of armament must be so planned as at all times to be capable of meeting its rivals on approximately even terms, and that for this its budget must make appropriate financial provision; at the same time providing means for the efficient undertaking of research and development work on any new method of military defence which the ingenuity of a scientific age may show to be possible. However embarrassing this double burden may prove, neither part of it can be safely neglected. It is natural, therefore, that every endeavour should be made to harmonise both parts so far as can be. It is necessary also that the interest of the general public, the body of ordinary taxpayers, be kept well alive, especially the important and influential

section composed of the technically educated. With this in view it is important that the general features of the programme be made known to those with the ability to understand them; though to ensure this without telling too much must inevitably lead to some risk of liberating facts capable of giving aid to rival Powers. Various countries employ their own means of ensuring protection against such eventualities, and in general there is probably more released in other countries than is customary here, especially some may think in America. One can certainly say that any account that gets published is more complete, and certainly easier to understand, when it relates to the older forms of warfare than when it attempts to portray the picture presented by some of the newer and more startling developments.

It is now realised that the great battleship with its groups of heavy guns shows sign of giving place to something more like a large aircraft carrier whose offensive equipment may be manned aircraft, batteries of long-range rockets, or even of modern missiles which can be radio-guided from the parent ship or from a manned aircraft or be self-guided by some form of radar device. Such guided missiles, as they are termed, may be planned to attack from ship to target, the latter being another ship, or an aircraft, or even a target far inland. They may be intended for offensive use or mainly for defence. Whichever type is taken, the work of detailed design, and the subsequent construction present problems of much difficulty: the best shape for the body, the most suitable kind of propulsion, and not least the best fuel to use, have all to be brought into review—and it is in reference to these factors that most of what is allowed to be published relates. Such publication can take various forms, but it is fair comment that the system of informing the public of new and important developments by "education through leaks" rather than by the older form of official releases carries the risk lest some facts or relationships become distorted. One form of such released information is seen in an interesting article published towards the end of last year in an American journal on the technical aspects of the problem of defending the United States against atomic attack, and quoted extensively in one of its leading technical journals. It is there estimated that by between 1957 and 1960 the chief interceptor fighter will be a delta-wing aeroplane, the F.102 ("Convair") with a reported speed well above that of sound and carrying a rocket missile with a self-guided electronic target-seeker with a speed of no less than 30 miles a minute.

One of the problems in the design of any guided missile must naturally be the method employed in the guidance itself and the degree of accuracy attainable thereby. This is in principle a matter of air navigation; difficult enough even when the ordinary means of fighter defence against fleets of bombers are concerned, but vastly more so when robot aircraft are used on both sides and the guiding intelligence has to be based on some form of automatic radar, and to take into account the rapid changes in relative position caused by the very high speeds of approach and manœuvre that are now possible, to say nothing of the great range in altitude of flight now possible and the variation in the air density in which the whole movement takes place. In the fire control mechanism customary in the battleships of a generation ago a difficult relationship between the several variables concerned had to be worked out by the gunnery experts; to-day a still harder one has to be solved, with everything now happening in three dimensions, with more variables and, on account of the far higher speeds concerned, much less time in which to complete the solution. A stern chase is proverbially a long one, and interception needs foresight. Furthermore, there is a greater restriction in the space available for the mechanism and in the actual load that can conveniently be carried in the air. However good and prompt may be the radar information there has still to be faced this complex air navigation exercise in interception with many and quickly changing variables to be worked out with speed and accuracy if an exceedingly costly missile is not to be thrown away. It may indeed be that it is the time taken to invent a really satisfactory solution for this complicated problem that makes the adoption of the guided missile as slow as it sometimes seems in overtaking its "conventional" predecessor in the defence programme.

Literature

Engineering Steels. By LESLIE AITCHISON and WILLIAM I. PUMPHREY. London: MacDonald and Evans, Ltd., 8, John Street, Bedford Row, London, W.C.1. Price £5 5s.

PROFESSOR AITCHISON and Dr. Pumphrey have set themselves the large task of providing comprehensive common ground between engineers and ferrous metallurgists. Their object is to explain the fabrication of steel, the properties of its many varieties, and its heat-treatment. There can be no doubt that from the metallurgical point of view they succeed to a large extent, and engineers will find in this massive book (900 pages, weight 3¾ lb) lucid explanations of the "why" behind their safety or ignorance factors.

The book could be (but is not) divided into four parts. The first five chapters deal with steel making processes and the nature and effects on mechanical properties of heat-treatment. Then there are six chapters on five broad classes of steel—"plain carbon," "alloy," "cold worked," "tool," "stainless, creep-resisting and heat-resisting" steels and "steel castings." Interpolated before steel castings is a chapter on surface hardening, which it would surely have been more logical to group with the chapter on heat-treatment. Thirdly, there are six chapters dealing with welding and brazing, machinability, scrap recovery, corrosion, and hardenability and its application from the American point of view. This last is contributed by Mr. R. D. Chapman, of the Chrysler Corporation, Detroit. The last part of the book is a single chapter called "The Heart of the Matter," which is a remarkable and scholarly thirty-three-page summary of metallurgy for engineers. There are thirteen appendices to the book, giving various useful data and procedures. They include a bibliography and a glossary of heat-treatment terms.

It will be seen that the arrangement of the book is designed to make it easy for the engineer to regard the specific aspect logically. The six chapters on the broad classes of steel are subdivided under mechanical properties, and the means (compositions and heat-treatment) by which they can be achieved are described and discussed with the meticulous attention to sources and bibliographies that one expects from such distinguished authors. To get an insight into the significance of the relevant factors the reader can cast back into the first part of the book; to consider subsequent treatment (e.g. by welding or for corrosion protection) he can cast forward. To the important and controversial subject of hardenability, as measured by end quench tests, the authors devote two chapters. Their own, in the first section of the book, comes to the conclusion with which few would disagree: "Hardenability tests are working procedures having the severely practical intention of grading different examples of the steelmaker's products and of assessing their potentialities." Mr. Chapman's conclusions in the last section of the book are very similar, and coming from Detroit are particularly significant. He writes: "... the Jominy end-quench test meets very successfully the demand for a procedure which assesses the hardening behaviour of a steel.... A procedure which may be followed ... consists in taking production components, determining their 'as-quenched' hardnesses across a section, and correlating these hardness values with the same hardness values along the length of an end-quenched test bar of the same steel." This bar is then used to deduce the cooling rates within the component, and hardness curves can then be used to predict the hardness that any particular steel would confer on any part of the component. This moderate use of hardenability tests accords well with metallurgical thought and practice in Great Britain, and is at variance with the extreme claims put forward by some American sources for hardenability as the ultimate and infallible suitability test in all circumstances, often almost regardless of the purpose for which the steel is to be used.

Valuable as this book will be, there are one or two respects in which its usefulness to engineers could have been improved. It is a particularly damaging criticism that the index is not as good as it should be. An engineer wanting information about mild steel will find no reference in the index to the notes on the subject on page 262. Seeking knowledge about deep drawing, he will find a reference at page 40 indexed, but not that at page 339, where the important problem of strain-ageing is dealt with. Omissions like this in the index, which is the part of the book to which engineers will turn most often, shake the reader's confidence.

Another surprising omission is that there is no list or summary of British Standards relating to steel, though three appendices list standards relating to castings and to welding. This is a fairly serious matter. An engineer wanting information on high yield structural steels, for example, might reasonably look for references to B.S. 968 or B.S. 548. He would find no such reference, though B.S. 968 is referred to briefly on page 603. Nor would the reader find "high yield," "low alloy high tensile" nor "high tensile structural" steel in the index, though low-alloy high-tensile steels have a special section in the chapter on welding. He would finally run his quarry to earth under "manganese, effect on mechanical properties," which in any case has no cross references to the welding chapter. Reference to the effect of small proportions of chromium on such steels he would not find at all.

These are blemishes on an otherwise fine piece of work, and can no doubt be removed

in later editions. Print and illustrations are well above some recent regrettable standards in technical publications, and the binding in particular is well finished.

Practical Design of Simple Steel Structures. Vol. 2. By DR. DAVID S. STEWART, M.I.C.E. London: Constable and Co., Ltd., 10, Orange Street, W.C.2. Price 25s.

THE issue of a third edition of this textbook (first published in 1929), of which Volume 1 was recently noted in our pages, has now been completed by the issue of Volume 2, which deals with the practical design of plate girders, columns, trusses and bridges. The main purpose of the work is the very necessary one of providing guidance to students, who have acquired a basic knowledge of structural theory and strength of materials, in the application of that knowledge to the practical design of structures.

That the book has, during the considerable period since its first appearance, adequately fulfilled its purpose as a bridge between theory and practice, there is no doubt and the new edition has been revised in conformity with the more recent standard specifications for buildings and bridges. It is to be regretted, however, that some space was not made available to take notice of the transition period now obtaining in structural practice by the increasing use of welding in replacement of rivets and bolts with the attendant changes in structural forms and connections. The contents of the volume are admirably presented, with clear diagrams and plates illustrating the various structures for which design calculations are given. These include a crane gantry plate girder of 40ft span; a roof truss of 55ft span; a lattice girder footbridge of 40ft span; a plate girder railway bridge and a Pratt truss highway bridge, both of 70ft span. The book contains adequate references in the appropriate places to relevant textbooks and specifications, and, despite the omission referred to, provides a substantial foundation to a practical knowledge of steelwork design for the young engineer.

SHORT NOTICES

2750: *Legend of a Locomotive.* By Harry Webster. Edinburgh 9: Thomas Nelson and Sons, Ltd., Parkside Works. Price 8s. 6d.—*How I Became an Engine Driver.* By Norman McKillop. Edinburgh 9: Thomas Nelson and Sons, Ltd., Parkside Works. Price 5s.—The first of these two books is the story of an L.N.E.R. class "A3" Pacific locomotive of the 1920s. In it the author gives the outstanding events in the running life of such a locomotive in express passenger service, from the time it was received at the London depot until it was withdrawn and allocated to less arduous duties elsewhere. All of the incidents are described from the viewpoint of the driver and fireman and individuals at the depot and elsewhere on the line who are associated with a locomotive, its running, maintenance and repair. As the author points out, although all of the persons and incidents described are fictitious, they are the sort of persons and incidents which were to be met on the railways of that time.

The introductory chapters of the book give general details of the design of an "A3" locomotive and describe graphically its reception at the depot, the allocation of its crew and their reactions, the running-in procedure, &c. Then a series of accounts are given, all of which are obviously based on experience, of a run north hauling the "Flying Scotsman"; troubles when a "hot box" occurs, its causes and repair; complications of hauling an excessive load and its effect on the locomotive; the causes and effects of a blown fusible plug; a record-breaking run, and a collision and its clearance by a breakdown gang. Each event is described in clear detail with all the relevant facts not normally appreciated or known by those outside the railways, presented in a most interesting and entertaining way.

The second book is in the nature of a biography giving a first-hand account of the steps in the career of a locomotive man from the time he enters the running-shed as a boy until he attains that most envied of all positions—a top link driver. At each stage, from cleaner to driver, the reader is given a clear impression of the training, the difficulties and the apprehensions experienced and the responsibilities which are involved in ensuring safe and reliable running on the railways. Many of the fine and interesting characters encountered in railway running service and the ways in which they impart knowledge are described from the viewpoint of the tyro himself.

Although these two books might be classified as "popular" fiction for the younger generation they will be read with interest and pleasure by many engineers and others who, although not associated with railways, still regard the steam locomotive with affection and respect. The authors have succeeded in presenting both the everyday work and the outstanding events connected with steam locomotive operation from an uncommon angle—that of the man actually doing the job. Perhaps some of the events and characters are overstressed but the insight given into jobs not generally fully appreciated or understood makes these books both entertaining reading.

U.S. Case Study Data on Productivity and Factory Performance: "Hand Tools." London: British Institute of Management, 8, Hill Street, W.1. Price 5s.—This is one of the reports compiled by the United States Bureau of Labour Statistics to give European managements an opportunity to compare production performance in their own factories with other plants. The reports give direct and indirect man-hours per operation; particulars of plant and product characteristics; work flow; materials handling methods; shop layout; standardisation; inspection, and production control. The report on hand tools deals in detail with the production in selected American factories of a flat file, a monkey wrench, and an expansive bit for woodworkers.

Economic Survey, 1954

THE Government's *Economic Survey*, 1954, was published on Tuesday afternoon by H.M. Stationery Office (Cmd. 9108, price 1s. 6d.). In form and content it is much the same as surveys of the last two or three years, the greater part consisting of an economic and industrial review of last year.

The second part of the document is entitled "The Present Outlook," and here it is emphasised that "the outstanding economic problem facing the United Kingdom is still that of paying its way abroad, and the needs of the balance of payments must continue to govern the pace of internal expansion." The maintenance of a rising level of international trade, the survey says, is a matter of particular concern to the United Kingdom which is so heavily dependent on imports and looks to exports of goods and services to provide something like one-quarter of its national income. The course of world trade, the survey continues, will depend very largely during the next twelve months on what happens to industrial production in the U.S.A. and Western Europe.

Dealing with activity in the United Kingdom, the survey suggests that it should be possible to avoid a serious fall in exports this year, even if there were to be some further decline in production in the United States, so long as countries in the sterling area and Western Europe co-operate in pursuing policies designed to maintain their mutual trade. It is stated that Government expenditure is likely to be "rather higher than last year." The defence programme remains a very heavy burden on the economy and the strains to which it gives rise are evident in the levels of Government expenditure and taxation as well as in its direct cost to the balance of payments. The survey points out that defence production levelled off during 1953, but since it was rather below its present level in the early months of last year, the total for 1954 will be a little higher than for 1953. But, the survey adds, demand for fixed investment will probably show some increase this year. Investment by the basic industries is on a rising trend and is expected to be appreciably higher this year than last, both in building and in plant and machinery. Furthermore, there will be physical resources available to provide for an increase in investment in manufacturing industry. Demand and activity, therefore, should be well maintained and production should be higher in 1954 as a whole than in 1953, although, the survey comments, "the prospects for the latter part of the year are inevitably uncertain." The output of the basic industries and services and supplies of raw materials should all be sufficient to support such an increase.

Finally, the survey affirms that it is the Government's primary aim to create a financial and economic climate which will help to stimulate the further growth of exports. Attention is again directed to the need for industry to eliminate practices which impede efficiency and to the need for continuing effort to raise the standards of technical training and organisation. The return of buyers' markets abroad, the survey notes, has two particular implications for the home economy; productivity in industry must be increased and costs and prices must be kept down. If in present circumstances the prices of our exports generally were to be pushed up by a rise in internal costs "we should be taking a short cut to national bankruptcy." This, it is emphasised, is what must happen if increases in productivity are regularly outstripped by rises in money wages, salaries and profits. But, the survey adds, if output per man rises substantially, an increase in real wages can be achieved at the same time as costs are reduced.

Books Received

Theory of Machines. By B. B. Low. London: Longmans Green and Co., 6–7, Clifford Street, W.1. Price 25s.

Oil in the Soviet Union. By H. Hassmann. London: The Oxford University Press, Amen House, Warwick Square, E.C.4. Price 30s.

Technische Kompositionslehre. By F. Kesselring. Germany: Springer-Verlag, Reichpietschufer 20, Berlin, W.35. Price Dmk. 39.

Shows and Exhibitions for Business Men. By J. M. Templeton. Surrey: Elliot's Right Way Books, Kingswood, Surrey. Price 6s.

Report on the Atom. By Gordon Dean. London: Eyre and Spottiswoode (Publishers), Ltd., 15, Bedford Street, Strand, W.C.2. Price 16s.

The Synchronous Induction Motor. By J. Griffin. London: Macdonald and Co. (Publishers), Ltd., 16, Maddox Street, W.1. Price 18s.

Non-Ferrous Foundry Metallurgy. Edited by A. J. Murphy. London: Pergamon Press, Ltd., 242, Marylebone Road, N.W.1. Price 70s.

Cathode-Ray Tubes. Consulting Editor, M. G. Say London: George Newnes, Ltd., Tower House, Southampton Street, W.C.2. Price 25s.

Rotating Amplifiers. Consulting Editor, M. G. Say. London: George Newnes, Ltd., Tower House, Southampton Street, W.C.2. Price 17s. 6d.

Analysis of Deformation. Vol. I: *Mathematical Theory.* By K. Swainger. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 63s.

Power and Process-Steam Plant. Edited by E. Molloy. London: George Newnes, Ltd., Tower House, Southampton Street, W.C.2. Price 17s. 6d.

Statistics for the Cost Accountant. By J. A. Reece. London: The Institute of Cost and Works Accountants, Ltd., 63, Portland Place, W.1. Price 5s.

Principles of Machine Woodworking: Routing. By A. H. Haycock. London: The Technical Press, Ltd., 1, Justice Walk, Lawrence Street, S.W.3. Price 10s. 6d.

High-Voltage Laboratory Technique. By J. D. Craggs and J. M. Meek. London: Butterworths Scientific Publications, Ltd., 88, Kingsway, W.C.2. Price 65s.

Electric Traction Handbook (Control). By R. Brooks. London: Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, W.C.2. Price 30s.

New Methods for Sheet Metal Work. Fourth edition. By W. Cookson. London: The Technical Press, Ltd., 1, Justice Walk, Lawrence Street, S.W.3. Price 16s.

Progress of the Tennessee Valley Authority

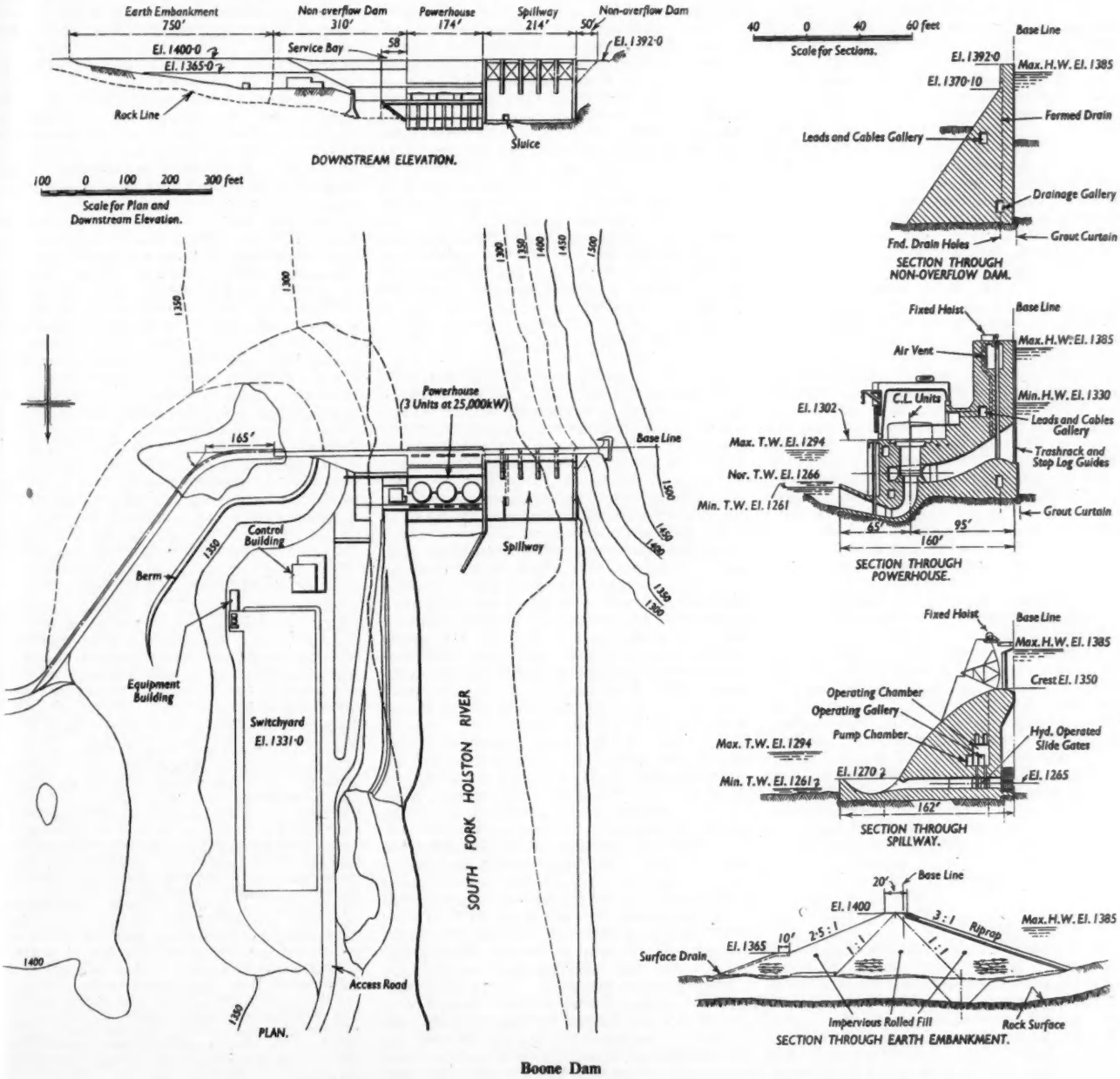
(By Our American Correspondent)

THE latest annual report to Congress of the Tennessee Valley Authority marks the end of the Authority's first twenty years as an enterprise challenging what has been called "the one great problem of the use of the earth for the good of man." At the time of its creation in 1933, T.V.A. constituted a departure from the traditional organisation of the American Federal Government. For the first time, a single agency was given responsibility for a unified approach to the development and use of the natural resources in a specific region. While none of the activities involved were new to the Federal Government, the uniqueness of T.V.A. lay in the range of functions that were being combined for administration within one agency in one area—a river valley. Unlike the Bureau of Reclamation, the Authority was established outside the regular departments of the Federal Government and was made accountable directly to the President and Congress.

Current Construction Schemes

During the fiscal year 1953, the T.V.A. had under construction fifty generating units at seventeen dams and steam power stations. Fifteen of these units were completed and placed in operation in the course of the year. They added 1145MW of capacity to the system, which is by far the largest addition to generating capacity to be put in operation by the T.V.A. in a single year. In addition, the U.S. Army Corps of Engineers placed in operation two 45MW generating units at its Wolf Creek dam on the Cumberland River, from which T.V.A. purchases power, and the Aluminum Company of America placed a small unit in operation at a new dam. The installed capacity of the integrated system was thus increased by 1245MW to a total of 5103MW. The eventual completion of the current construction schemes is now scheduled to bring the total installed capacity of the integrated system to 9939MW by December, 1956.

Certain details appertaining to, and a map showing the sites of, the seven major steam power stations which are being built by the T.V.A., were published in THE ENGINEER of June 5, 1953. Much progress was made during the past year in the construction of the Shawnee steam power station on the Ohio River, which was started in January, 1950, specifically to provide power for a gaseous diffusion plant being built by the Atomic Energy Commission near Paducah, Kentucky. The first four 135MW turbo-generators at this plant have now gone into operation and the remaining six are scheduled to commence production in 1954 and 1955. On account of delays in the manufacture of the first four 135MW turbo-generators for the Kingston steam power station on the Tennessee River, these units will not go into operation until sometime in 1954. The construction of four other units, each of 180MW capacity, was under way during the year and recently Congress provided funds for commencing an additional unit, making nine in all. When all nine units are in operation, the plant will have an installed capacity of 1440MW. The last two of six 112·5MW generating units at the Johnsonville steam power station on the Tennessee River were placed in commercial operation during the past year, and the plant now has an installed capacity of 675MW. The first four of six 112·5MW turbo-generators at the Widows Creek steam power station on the Tennessee River have gone into operation, and the remaining two units are expected to go on the line during 1954. The construction of the John Sevier steam power station on the Holston River was started in October 1952. The plant was originally planned to comprise only two 180MW units,



Boone Dam

but funds were allocated by Congress in July, 1953, to allow a third 180MW unit to be constructed. Foundation work at the Colbert steam power station on the Tennessee River has been completed and the erection of steelwork is in progress. The first of its four 180MW turbo-generators is scheduled to begin operation in October, 1954, with the remaining three units to be in production by the end of 1955. Recently, preliminary construction work was started at the Gallatin steam power station on the Cumberland River, which will have the largest generating units in the T.V.A. system. The plant will comprise an initial installation of two 225MW turbo-generators operating at a steam pressure of 2000 lb per square inch and a temperature of 1050 deg. Fah.

During the past year construction was completed of the Boone dam, which is situated on the south fork of the Holston River in Eastern Tennessee. The dam was closed in December, 1952, and its three 25MW generating units were placed in operation in March, June and September, 1953, respectively. Details of the design of the dam and its auxiliary works are given in accompanying drawings. The dam consists of a concrete gravity structure incorporating the power station and spillway with an earth embankment on the right bank side. The maximum height is 140ft and the overall crest length about 1500ft, of which the earth embankment comprises 750ft. The reservoir will have an ultimate storage capacity of 211,000 acre-feet. The spillway section is 214ft long and comprises five openings, each controlled by a 35ft by 35ft radial gate. Fort Patrick Henry dam—the twentieth dam to be constructed by the T.V.A.—is situated 10 miles downstream from the Boone dam. Its construction started in June, 1951, and the closure of the dam took place on October 27, 1953. The design of this concrete gravity structure closely resembles that of the Boone dam; there is a power station situated adjacent to the spillway section, which is 214ft long and comprises five openings, each controlled by a 35ft by 35ft radial gate. The dam will have a maximum height of 95ft and an overall crest length of 670ft, and its reservoir will have an ultimate storage capacity of 29,850 acre-feet. The first of its two 18MW generators recently went into operation.

Five new generating units in three existing dams were placed in operation during the past year, adding 150MW of capacity to the T.V.A. system, while work is continuing on an additional six units having a combined capacity of 208MW. Two 36MW units were placed in operation at the Pickwick Landing dam, bringing the total capacity at this plant to 216MW. At the Hales Bar dam two 24·3MW units were placed in operation, bringing the total plant capacity to 99·7MW. At the Cherokee dam, a new 30MW unit was placed in operation in January, 1953, while work continued on a fourth unit which will complete the 120MW capacity of this scheme. Major equipment has been ordered for a new pump turbine unit to be installed in the power station at the Hiwassee dam. The unit will be of 59·5MW rating, bringing the generating capacity at this dam to 117·1MW. Acting as a pump, the reversible unit will be able to return water to the reservoir at the rate of 3900 cusecs. The reversible unit will act as a generator to produce power during hours of peak load and as a pump during off-peak hours. Its initial operation is scheduled to take place late in 1955. Progress was also made in the installation of a third 67·5MW unit at the Fontana dam, which will bring the scheme to its ultimate capacity of 202·5MW. Construction work was started on the installation of the fourth unit at the Douglas dam. When this unit is placed in operation this spring, the dam will have an installed capacity of 112MW.

Flood Control and Navigation

The closure of the Fort Patrick Henry dam has brought to thirty the number of major water control schemes in the Tennessee River system. At the beginning of the past year, T.V.A. had 7,180,000 acre-feet of useful water stored in the reservoir system. Considering the loads that were scheduled for the power system, this was somewhat less than the amount desirable. During the record dry weather of the autumn, this was drawn upon to maintain the stream flow for power production and navigation purposes. In an average year this process automatically lowers the reservoirs to provide the storage space required for the regulation of flood waters during the winter and spring rainy seasons, but during the past year the draw-down was much greater than necessary for this purpose. As the season of heavy rains passed and the danger of floods subsided, the reservoirs were allowed to fill until May when the run-off was no longer sufficient to provide water for storage after supplying the current need for the generation of hydro-electric power. At the close of the fiscal year, the reservoirs held 6,690,000 acre-feet of useful water, a reduction of 490,000 acre-feet, or 7 per cent, from the same date the year before.

No important operations for flood control were necessary during the year because of the amount and the timing of rainfall. Due to the drought more storage space was available than the amounts required by the operating priorities for this purpose—11,800,000 acre-feet in early January and 10,400,000 in the middle of March, near the end of the flood season. At the city of Chattanooga, a minor flood which would have reached a stage of 32ft under natural conditions was reduced to an actual crest of 21·4ft. The flood would have done only minor damage. There were no floods on the Ohio and Mississippi rivers at Cairo, Illinois, during the year.

With regard to river navigation, a small amount of dredging has brought the channel to its full design depth and width; it provides a channel with a minimum depth of 11ft, accommodating barges of 9ft draught, and a minimum width of 300ft from the mouth of the river to Knoxville, over a distance of 630 miles. This part of the river connects the Tennessee Valley with the improved American inland waterway system of 7000 miles. Traffic has continued to grow rapidly. In 1952, the river carried 5,700,000 tons and 797 million ton-miles. These figures were respectively 50 and 37 per cent above those of the previous year. In the first nine months of 1953, about 750 million ton-miles of traffic were carried, while in 1933 the river carried only 33,000,000 ton-miles.

Power Generation

The T.V.A. system generated 23,744,919,000 kWh during the year, of which hydro-electric plants produced 13,933,290,000kWh and steam-electric power stations produced 9,811,629,000 kWh. In addition to the power generation, T.V.A. obtained 2,714,231,000kWh in interchange and purchased 888,541,000kWh from other utility systems, making a total system input of 27,347,691,000kWh. Because of the drought, the hydro-electric power production was about 10 per cent less than in the previous fiscal year, but with much new steam-electric capacity coming into service the production obtained from the steam power stations was more than doubled. The power supply situation remained very tight during most of the year. The severe drought sharply reduced the supply of hydro-electric power, and, primarily because the manufacturers failed to meet delivery schedules, there were serious delays in the installation of certain steam-electric generating units.

In 1953, the municipal and co-operative distributors of the power generated by the Authority were serving 1,300,000 consumers, or more than four times as many as there were in 1933. A part of this increase is due to the greater population, which has increased 19 per cent in the area served by T.V.A. between 1930 and 1950. A much larger part of the increase has resulted from the extension of service to rural areas. In 1953 there were over 585,000 rural consumers of power produced by T.V.A. The average consumer in the area uses much more power to-day than he used in 1933 and much more than the average consumer in the United States as a whole. In the fiscal year 1953, the average residential consumer of T.V.A. power used 4314kWh, while the average in the United States was 2257kWh per annum. In the Tennessee Valley the average consumer increased his use by 387kWh over the year before; in the country as a whole the increase was 166kWh.

Chemical Engineering Activities

In the field of chemical engineering, works of the T.V.A. at Muscle Shoals, Alabama, and Columbia, Tennessee, produced 42,000 tons of calcium metaphosphate, 141,000 tons of concentrated superphosphate, 26,000 tons of fused tricalcium phosphate, and 197,000 tons of ammonium nitrate fertilisers during the year. Advances were made in research on development of other processes and materials, particularly in producing nitric phosphates, diammonium phosphates, and concentrated superphosphate using mixtures of sulphuric and phosphoric acids. Most of the phosphate and nitrogen fertilisers produced by the T.V.A. during the year went into programmes designed to improve the use of fertilisers on the farms. The bulk of the materials was used on close-growing hay, small grain and pasture crops which help conserve the soil. A small proportion of the fertiliser output was used in test demonstrations on private farms in twenty-one States. In the Tennessee Valley the test demonstrations have been instrumental in encouraging readjustments in the use of the land, including shifts from row crops, such as corn and cotton, toward cover crops, such as hay, small grains and pastures. These adjustments conserve soil and water, encourage the growth of livestock and dairy farming, and at the same time protect the Tennessee Valley watershed. Over the years, some 68,000 farmers, either singly or in areas embracing small communities, have participated as test demonstrators, and many thousands more have profited from their experience.

The operations and accomplishments of the T.V.A. have attracted attention not only in the United States, but throughout the world. This has been true particularly since the end of the war, a period when governments and leaders in many lands have sought to improve the lot of the people by improving their use of natural resources. Last year more than 2500 visitors from abroad inspected the works of the T.V.A. and studied its operations in the Tennessee Valley. Using a regional approach to the unified development of resources, the Authority has accomplished much in the last twenty years. An entire river system—the fourth largest in the country on the basis of stream flow—has been controlled and put to work. Large amounts of power have been developed and channelled into homes, farms and factories, including two large atomic energy plants. The development of new and better fertilisers has helped to open the way to better farm management and to greater diversity and flexibility of production—all leading to the diminution of erosion and the improvement of agricultural lands in the valley.

Books of Reference

Directory of Shipowners, Shipbuilders and Marine Engineers, 1954. London: Tothill Press, Ltd., 33, Tothill Street, Westminster, S.W.1. Price 40s.—*The Directory of Shipowners, Shipbuilders and Marine Engineers*, 1954, which has just been published, is the fifty-second edition of this work and has been revised, brought up to date and new material added. There are a number of sections, the largest being that which relates to shipowners and the next in size being concerned with shipbuilders. In the former, lists of shipowning companies are given together with information about individual services and details of the ships in the various fleets, while the latter gives particulars and capacity of the shipyards and marine engineering establishments. Included in both sections are the names of directors and of the commercial and technical executives. There is a comprehensive list of consulting naval architects, marine engineers, and surveyors; another list acts as a guide to the trade organisations and technical societies connected with industry. Details of the various Government departments are included and also lists of the surveyors and outports of the classification societies. A total of five indexes cover various aspects of the industry and give, in alphabetical order, the names of ships, shipowners, ship and engine builders, this latter group being further divided in order of countries and towns. Another index records telegraphic addresses and there is a general index and, finally, a personal index to the officials and personnel of all the companies.

Australian Built "Sabre" Jet Fighter

EARLY in 1937 the Australian Government decided to establish the production of military aircraft in Australia and within two years the Commonwealth Aircraft Corporation Proprietary, Ltd., had built the "Wirraway," a North American advanced monoplane trainer, powered by a "Wasp" engine, which made its first flight in March, 1939. Since then the Corporation has manufactured both medium range bombers and high-speed fighters, in addition to the Rolls-Royce "Nene" and "Merlin" engines, but it was not until August of last year that it completed the first aircraft, wholly manufactured in Australia, to fly faster than the speed of sound—a "Sabre" jet which on its first official flight reached 670 m.p.h. This "Sabre" jet marked a significant stage in the development of the Australian aircraft industry in that its design incorporates many new features and it is in fact a much more powerful fighter than the original "Sabre" jet built by the North American Aviation Company. The first-rate performance of the American "Sabre" jet has been amply demonstrated on active service in Korea, but pilots were unanimous in recommending increased engine thrust and heavier fire power. Accordingly, in deciding to build an Australian version, the Commonwealth Aircraft Corporation substituted a Rolls-Royce "Avon" engine for the American General Electric "J47" and equipped the aircraft with heavier armament in place of the 0·5in calibre machine guns of the original "Sabre." The larger "Avon" engine consumes 25 per cent more air than the smaller General Electric jet engine; and this change, with the heavier armament, required a great number of other changes to be made. In fact, only about 40 per cent of the original fuselage structure has been retained. The change in engines made it necessary to increase the size of the air intake duct, and it created many problems of cooling, venting, access and installation. In addition the fuselage fuel cells have been rearranged, accessories and equipment have been repositioned and the location of the transport joint for removal of the rear fuselage for engine access has been revised. All through, however, the basic lines of the "Sabre" have been retained so that the flight characteristics of that well-proven aircraft remain undisturbed. The "Avon" engine, while giving considerably more thrust and consuming more air than the "GE J47," occupies approximately the same space, since its overall dimensions are much the same. The mounting points are considerably different, however, and this, combined with the fact that the Rolls-Royce engine is several hundred pounds lighter, meant that the engine had to be repositioned much farther aft. This preserved the original centre of gravity position, one of the essentials of the modification. The new location of the main engine trunnions made it convenient to move the transport joint by which the whole rear end of the fuselage is removed, farther aft, thus permitting the engine to be fully supported in the front fuselage structure. The side panels of the fuselage were redesigned to incorporate access holes for the front engine mount, certain engine accessories, spills for the compressor bleed valves and balance piston vents, and cooling air intakes and exits. In general, on this work, the basis of the original design has been retained, although the disposition of units has been considerably altered.

Mention has been made of the greater air mass flow requirements of the "Avon" engine. This, in fact, appeared to be one of the most serious difficulties presented in attempts to step up the performance of the "Sabre," but it was overcome in a simple manner. The nose entry of the aircraft made it possible to split the front fuselage horizontally, and insert in the split a wedge of structure, dropping the lower line of the fuselage by 3½in at the front. The effect was to open the mouth of the duct, rather in the manner of a jaw, the required 25 per cent extra area, fading out the increase in duct cross-sectional area as it went back to the engine face. To save as much of the original structure as possible during this change, the fuselage frames in the region of the nose had, in most cases, extension pieces let into their sides. Complete new frames were, therefore, not required except in special cases. The split frames were then covered by a wedge-shaped strip running fore and aft on the duct surface and by extensions to the skin panels on the outer surface. This comparatively simple modification saved hundreds of hours of engineering and tool manufacture on the nose structure and left undisturbed the complicated nose-wheel fittings and intercostals in the lower half of the fuselage. It had a secondary beneficial effect also in that it increased the static angle of attack of the wing on the ground since the nose-wheel pivot was lowered relative to the wing datum. This resulted in an improvement in take-off performance. The installation of the "Avon" engine brought in its train a series of new problems on the cooling of the aircraft structure adjacent to the engine. The fuselage structure in the region of the power plant is divided into two compartments separated by the engine fire-wall. Each compartment is strictly sealed off for fire-proofing and each therefore is a separate cooling and ventilation problem.

Zone 1, the forward section of the two compartments, includes all the fuel lines, the engine control units, fuel pumps and hydraulic pumps. There is no great source of heat in this region as the engine is comparatively cool here, but it is necessary to ventilate the area to remove fuel and oil fumes. All drain lines from fuel pumps and filters have been carefully piped overboard to limit the fire risk. The compartment is ventilated in flight by means of small N.A.C.A. type flush entries on the outer skin, exhausting through an opening on the top centre line. In static conditions on the ground when no rammed air is available through the side entries, a cooling flow is induced through the top exit by means of the three balance piston vents. These exhaust into the duct at the exit and act as an ejector air pump. Zone 2 presented a different problem as in this compartment, which includes the engine cans, exhaust cone and tail-pipe, limiting the fuselage structural temperature was of greater importance than mere ventilation. A strict limitation of 200 deg. Fah. was placed on the light alloy structure, caused by the sudden drop in the strength of the material when subjected to higher temperatures for any reasonable period of time. Following the practice used in the original design, all longerons and major frames aft of the engine fire-wall were made of corrosion-resistant steel, fabricated from sheet, but the skins and frames of lesser importance were retained in the 75S light alloy originally used. Great care has been taken to isolate services of major importance from the remainder of the region, and all control cables and hydraulic lines run in stainless steel tunnels along the top of the fuselage. The emergency hydraulic pump and associated gear also in this area is enclosed in stainless steel boxes to protect the essential flight services from damage in the event of fire in the hot region of the engine. This zone is cooled by a flow of air between engine and structure, entering the compartment through three small flush entries on the outer skin, and exhausting through an annulus around the jet pipe nozzle. In flight, the pressure recovery from the entries provides the required flow of air, but to cover the case of engine running at full thrust on the ground and during take-off, an aspirator has been designed at the annular exit.

A considerable amount of experimental and developmental work has been done to produce an efficient but light air pump for this purpose. In principle, the unit is very simple, consisting of a line bleeding air from the high pressure stage of the axial flow compressor, feeding a tube bent in the form of a circle positioned in the cooling air exhaust annulus, coaxial with the jet pipe. A series of ¼in diameter holes in this tube project streams of high pressure air aft, thus entraining sufficient air from the annulus to produce the necessary cooling flow along the inside of the fuselage. This pumping action is required at all times when the aircraft is stationary or at very low speed, so it is arranged that the line from the engine compressor is automatically closed when the undercarriage is retracted. None of the valuable compressor air is then lost when maximum power is required in flight. Early in the project it was decided to make as much use as possible of full-scale testing and space investigations, and these have proved to be well worth while. Mock-ups of both engine and armament installations were made to fix the disposition of, and access to, the many units involved. These were made along usual lines, using wood for the majority of structural members and representing equipment by wooden blocks. These mock-ups were followed, however, by a more complex rig which represented, in metal, the frames, webs and intercostals of all the fuselage structure. The accuracy of this metal work was of the same order as the finished aircraft and every piece of equipment has been mounted in its correct position in the structure. This has served two purposes. In the first place it confirmed the clearances between equipment lines, engine and structure, and the access to these units. But of more importance, it also served as an assembly jig for the first-off hydraulic and fuel lines and electric cables. Each line was tailored to fit and placed in its correct position. The open nature of the rig, having no skin or duct, enabled many men to work simultaneously on this job, a condition not possible on an assembled fuselage.

In this way pipes and cables for the prototype aircraft were assembled long before the fuselage structure was in a fit state to receive them, and the difficulties and problems of the prototype equipment installation were overcome while the structure was still under manufacture. This rig has, in fact, provided a training ground for the key assemblers who now form the backbone of the production final assembly line, and their knowledge and experience were gained with no interference with the structural assembly. The idea saved many weeks in the critical period when the first aircraft was taking shape, and has repaid many times over its initial cost and trouble. Reference has already been made to the problem of providing sufficient cooling flow along the fuselage to protect the structure from excessive temperature, both in flight and on the ground. This was recognised as being a case for practical investigation, and a dummy fuselage was constructed consisting of all the major structure from the face of the engine to the propelling nozzle. This was shipped to England and, with the co-operation of Rolls-Royce, was tested in a static rig with an "Avon" engine installed, under all conditions of engine thrust. Temperatures attained by the structure were measured, and in this way a complete knowledge of the efficiency of the aspirating system under static conditions was obtained. As a result of these valuable tests, some adjustments were made to the cooling air intakes and, in addition, two small ventilation doors in the top of the fuselage above the jet pipe were incorporated to prevent local overheating due to lack of circulation after shut-down. These doors are wired to open when the undercarriage is extended and to close thermostatically when the temperature falls to a pre-set level. Of those static cases tested, shut-down provided the most severe temperature conditions for the structure and, as a further precaution, a procedure was laid down to prevent engine shut-down straight from full thrust conditions.

One of the most important of the experimental structures used during the manufacture of the prototype aircraft was the static test fuselage. This was a complete assembly of the fuselage structure from nose to tail, which was subjected to the loads corresponding to the four major design cases. To this end, a universal testing rig was constructed to hold the fuselage and to apply by means of hydraulic rams, the concentrated loads from the horizontal and vertical tail surfaces, the nose leg, cockpit, canopy and wings. Strain gauge measurements were used to the full during these tests and a comprehensive knowledge of the strength of the fuselage structure was acquired. This complete strength

checking by experimental means was completed before the first aircraft was permitted to fly, as it served not only as a check on the major structural components, such as the longerons, but confirmed the detail design of skin cut-outs, frames and local attachments. The construction of the "Sabre" air frame has introduced a number of processes and techniques which are not only new to C.A.C. but to Australian industry. The wealth of knowledge that has been built up by North American Aviation Company has been drawn on and C.A.C. has overcome the initial difficulties and teething troubles always associated with new devices. The materials used in the manufacture of the aircraft structure are in the main 75S aluminium alloy and corrosion resistant steel of the 18/8 high ductility type. Both these materials presented problems in the forming and fabrication due to their high strengths and other properties. To maintain an exceedingly high standard of skin finish, all external counter-sinking for rivets is done by coin-dimpling, a double action process which forms a dimple with a very sharp lip radius. As this forming must be done in the hot condition, the dimpling tools are electrically heated and a precise combination of heat and pressure is essential to produce crack-free satisfactory dimples. Considerable experimental work has been necessary to achieve this result, and its success is apparent, in the smooth external skin of the "Sabre," which carries no paint or synthetic finish to cover the blemishes of fabrication. The coin-dimpling procedure has been combined with the use of heat treated rivets of 24S aluminium alloy in the sizes $\frac{1}{4}$in and larger, used from ice boxes distributed throughout the plant and a system of timing has been developed to ensure that rivets are driven in a certain period after removal from the stabilising conditions of the ice box. New manufacturing processes have also been developed and the advances made in this field are apparent in such machines as the Billeter planer with an Onsrud milling head for wing skin sculpturing, the Hufford stretch-presses, the seam welders and copper brazing furnaces. This modern equipment has no equal in Australia, and its use has meant much to the success of the "Sabre" project. With the order for "Avon" "Sabres," activity at C.A.C. has reached a pitch reminiscent of the war production years. "Winjeel" trainers, the future basic trainers of the R.A.A.F., will shortly be leaving the plant alongside the "Sabres" and, in producing these two aircraft, C.A.C. is playing an important role in re-equipping the R.A.A.F. with modern weapons.

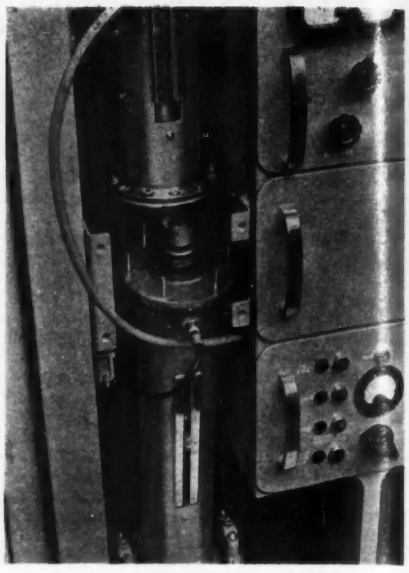


Fig. 2—R.F. Penultimate Amplifier with Output Resonant Circuit Hydraulically Raised and Input Circuit Tilted Forward for Removal of Output Valve

V.H.F./U.H.F. Transmitter for B.B.C. Experimental Work

SIX v.h.f./u.h.f. transmitters for experimental work by the B.B.C. on frequency bands III, IV and V are being built at the Mullard Research Laboratories, Redhill, Surrey. The first of these transmitters is designed for use on band III, which is 174–216 Mc/s. It was completed recently and views of the equipment are reproduced in Figs. 1, 2 and 3. Development work on the remaining five transmitters (a second one for band III and two each for band IV, 470–585 Mc/s, and band V, 610–960 Mc/s) has been completed and their construction is well advanced.

These transmitters were developed at the Mullard Research Laboratories to a specification laid down by the B.B.C. Although they are designed to meet these specific requirements, the transmitters are capable of being adapted for use as small-power television transmitters operating anywhere within the frequency range covered by bands III, IV and V. It is also possible that the experience gained in the development of these transmitters may be of use when considering the design and development of unusually wide frequency range, tunable transmitters for communications and other purposes.

One of the main design requirements of the new transmitters is that, for reasons of economy, they should operate at relatively low powers, which means that field strengths are very low compared with those normally associated with broadcast transmitters, and that an unusually high order of transmitter stability is necessary so that narrow-band receivers of extreme sensitivity may be used. To ensure that valid propagation measurements can be made at the receiver, it is important that the stability of amplitude should also be high.

In practice, the transmissions will normally be square-wave modulated. The signals, at a fundamental modulation frequency of 1000 c/s, will be extracted in the receiver by means of filters. The amplitude of the signal will then be used to provide the propagation record. For investigations of multi-path transmissions and echo effects—factors of significance when operating in the higher frequency ranges—use will be made of the pulse-modulation facility also available.

The main technical advances embodied in the transmitters are the wide frequency range of tuning and the fact that only one r.f. circuit is used for both pulse and square wave-form conditions of modulation. These improvements have been made possible by using variable length, coaxial resonant lines for the output, the preceding and, in some instances, the earlier stages.

Another characteristic of the equipment is that it is so designed to allow routine measurements at different frequencies to be taken by non-technical personnel. The transmitters are intended for operation in a van, and to ensure reliability under such conditions of service the transmitters must be capable of coping with large variations in mains supplies. This condition has been met by so designing the power supply unit that the equipment will operate satisfactorily with single-phase a.c. supplies from 200V to 250V, 45 c/s to 55 c/s, permissible fluctuations around the nominal voltage being +5 to −15 per cent. The power consumption of the equipment is about 3kVA.

Improvements are claimed in the early stages of the circuit by the use of the Mullard v.h.f. tetrodes "QQV03–20" and "QQV06–40" These valves use a common cathode and common screen for the two tetrode sections, which results in improved efficiency, power gain and heater economy. These valves also have built-in neutralising capacitors, enabling the circuits to be simplified.

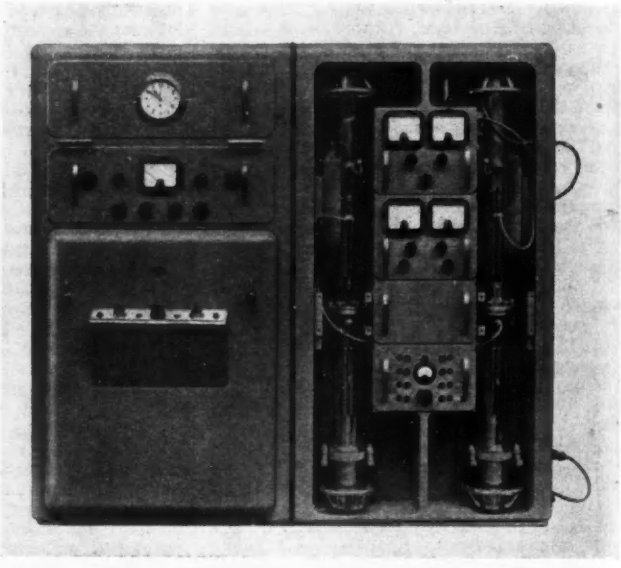


Fig. 1—Transmitter for Experimental Work on Band III with Right-Hand Cover and Top Left-Hand Cover Removed

The equipment, which is designed to feed into a 70-ohm aerial, comprises eight units. They are a power supply unit, a modulation waveform generator, a frequency generator and multiplier unit, a square waveform modulator, a pulse waveform modulator, a fault alarm and safety unit, an r.f. drive unit, and an r.f. power amplifier/oscillator unit. These units are mounted in two bays of a cabinet (Fig. 1), 6ft high by 6·6in wide by 2ft 9in deep. The weight of the equipment is approximately 2000 lb.

All units are so designed that they are readily accessible from the front. The left-hand section of the cabinet houses (from top to bottom) the modulation waveform generator; the frequency generator and multiplier unit; and the power unit. The power unit is trolley mounted and the other units are mounted on retractable runners to facilitate servicing. Similarly all the units on the right-hand section (except the two r.f. stages) are retractable (Fig. 3). For the servicing or replacement of the output and driver valves a hydraulic jack is incorporated in the equipment. This enables the heavy upper casing of the valve mounting to be raised (Fig. 2); the lower casing in which the valve is mounted can then be tilted forward and the valve withdrawn

The equipment is designed to withstand transport under vibration and shock conditions. The usual interlocks and safety systems are incorporated to protect personnel and to prevent overloading of vital valves and other components. A clock is also provided on the front panel of the equipment so that timing and identification signals can be automatically transmitted at regular intervals. Three removable

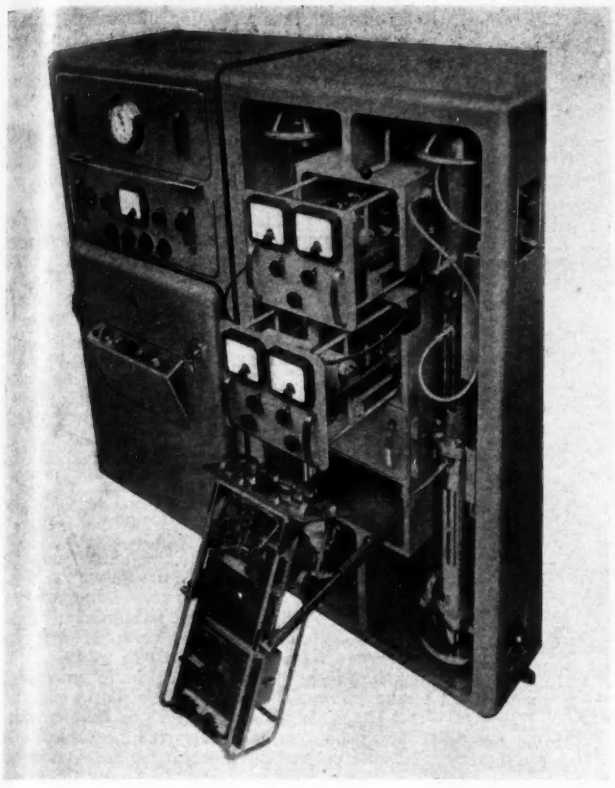


Fig. 3—Right-Hand Units Partially Withdrawn Showing, from Top to Bottom, Square Waveform Modulator, Pulse Waveform Modulator, a Spare Panel. The Fault Alarm and Safety Unit is Fully Extended and Tilted for Servicing

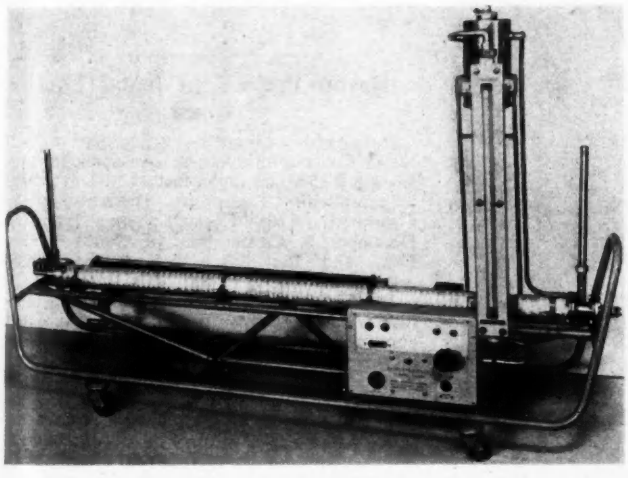


Fig. 4—Very-Wide-Band Dummy Load for Power Measurements at Very High Frequencies

covers with apertures for the instrument dials are fitted on the front face of the cabinet. In Fig. 1 the top left-hand cover and the right-hand cover have been removed to show the racks.

The six transmitters are designed to work at any frequency within their range and they provide for both square waveform and pulse conditions of modulation. With both forms the peak power delivered is maintained constant to better than $\pm\frac{1}{2}dB$ over any two-hour period, after the lapse of a thirty-minute initial warming-up time.

The repetition frequency under 100 per cent square waveform modulation conditions is 1000 c/s, quartz crystal controlled so as to give a short-term stability of better than 0·002 per cent. The change-over edges are of the order of 10 microsecs. The power outputs for the three types of transmitters are as follows :—

Band III, 150W C.W., i.e. 600W peak.
Band IV, 100W C.W., i.e. 400W peak.
Band V, 50W C.W., i.e. 200W peak.

The carrier frequency stability is ± 1 part in 10^4 over a period of forty-eight hours, which is achieved by frequency multiplication from a crystal-controlled oscillator working in the range 5–10 Mc/s. Facilities are also provided under the square waveform modulation condition for the signals to be interrupted for two to four seconds at intervals of thirty seconds, or one to two minutes at intervals of sixty minutes, controlled by an accurate clock mechanism.

The repetition frequency under pulse modulation conditions is also 1000 c/s, quartz-crystal controlled. The pulse duration is 0·5 microsecond. The peak pulse power under all conditions is greater than 10kW, and the frequency stability is of the order of ± 1 part in 10^3, which is achieved without resort to crystal control, the output stage being used in the self-oscillating condition.

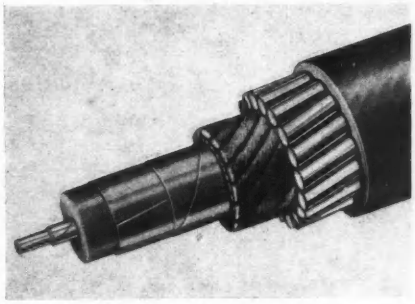
In conjunction with the development of these six B.B.C. v.h.f./u.h.f. transmitters, Mullard Research Laboratories has designed a very-wide-band dummy load (Fig. 4), which provides an accurate means for measuring the power output over the unusually wide frequency range covered by these transmitters. This instrument consists essentially of a short coaxial line filled with carbon tetrachloride, the inner conductor consisting of a thin gold film on a glass rod. It presents a substantially resistive input impedance of 75 ohms at frequencies from 100 Mc/s upwards. The power absorbed by the dummy load is measured in terms of the temperature rise in the carbon tetrachloride cooling liquid between inlet and outlet of the dummy load. The maximum power handling capacity of the instrument is 600W, and the power measurement accuracy is $\pm 1{\cdot}5$W or ± 2 per cent, whichever is the greater.

First Transatlantic Telephone Cable

As reported briefly in our issue of December 4, 1953, page 746, an agreement has been signed by the American Telephone and Telegraph Company, the British Post Office, and the Canadian Overseas Telecommunication Corporation, for the provision of a submarine telephone cable system across the Atlantic Ocean. It will be owned jointly by the three administrations named above and the project will take three years to complete at a cost of £12,500,000. The British contribution will be the production of a major part of the cable and of the submerged repeaters between Newfoundland and Nova Scotia, and the laying of the submarine cables by H.M.T.S. " Monarch." The remainder of the cable, and the submerged repeaters for the main crossing, will be produced in the United States. An initial order for the manufacture of nearly 90 per cent of the first of the two telephone cables to be laid between Oban and Newfoundland has been placed by the Post Office with Submarine Cables, Ltd., a company which is jointly owned by Siemens Brothers and Co., Ltd., and The Telegraph Construction and Maintenance Company, Ltd.

The new cable system will provide for thirty-six simultaneous conversations. It is proposed to allocate twenty-nine circuits for traffic between New York and London, and six circuits between Montreal and London. From the terminal cities the circuits will connect with the telephone systems of the respective countries ; in addition circuits can be extended from London to Continental Europe via existing telephone facilities.

The two cables across the Atlantic will be ten times as long as any other so far used for submarine telephony, and the first to be laid in depths exceeding 1000 fathoms. Such a project[1] is made possible by the development of submerged repeaters, consisting of electronic amplifiers in watertight and pressure-resisting casings, to be laid with the cable and rest on the sea-bed. With carrier frequency operation, a band of 144 kc/s is occupied by the thirty-six speech channels. For the main crossing of 1950 nautical miles from Scotland to Newfoundland, the submerged repeaters will be of the



Type " B " cable for intermediate depths:
Diameter over inner conductor 0·160in.
Diameter over polythene insulation 0·620in.
Thickness of outer copper tapes 0·016in.
Armour, 18 No. 8 (0·165in.) galvanised steel wires.
Overall diameter 1·4in.
Weight in air 112 cwt/n.m.
Weight in water 80 cwt/n.m.

Stepped Section of the First Atlantic Telephone Cable

kind developed by the Bell Telephone Laboratories and installed in the Key West-Havana cables[2] in 1950. They are designed to be included under the cable armour, forming a bulge about 3in in diameter, tapered off at each end to the cable diameter, the length being about 20ft. The bulge is sufficiently flexible to pass through the gear of a cable ship, so that laying and recovery in 2500 fathoms are practicable. Only one-way transmission is provided, which necessitates two cables, each transmitting the frequency band from 12 to 156 kc/s. Over fifty repeaters spaced at intervals of 37 nautical miles will be laid in each cable, with three valves in each repeater.

For the 310 n.m. stretch from Newfoundland to Nova Scotia in a depth of 250 fathoms, " lump " repeaters[3] developed by British engineers will be used. So far nineteen submerged repeaters of this kind have been installed in cables in European coastal waters, and another seven modified as for the new project are to be included in the Aberdeen-Bergen cable now being manufactured at Greenwich. With the greater space available, filters permitting two-way working can be accommodated ; therefore, one cable suffices to transmit two frequency bands which provide separately for the speech channels in the two directions. Repeater spacing will be less than for the main crossing owing to the greater attenuation at the higher operating frequency. From Nova Scotia a microwave radio-relay link will connect for 350 miles overland to the United States.

The cables will be of the single coaxial type[4]

which have been already tried out in shallow water. They will be insulated with polythene, mixed with 5 per cent of polyisobutylene or butyl rubber, and a small amount of antioxidant to prevent slight deterioration of qualities during processing : polythene,[5] it may be recalled, is a synthetic thermoplastic hydrocarbon (with dielectric constant 2·3, power factor 0·0003 and very high resistivity) discovered by Imperial Chemical Industries in 1933. An important factor in the processing of polythene is its melt viscosity. It is measured by the extrusion rate from a standard plastometer[6] called a " grader," at specified temperature and pressure.

In the present case a hard polymer will be used, extruded on to the inner copper conductor, which has a composite structure of a 0·131in wire surrounded by three tapes 0·0145in thick. The diameter of the insulator will be 0·620in. Surrounding the insulator is the outer conductor, consisting of a layer of six copper tapes applied with a long lay, and held in position by a copper binder tape and a protective tape applied with short lay. The jute serving, galvanised steel armour wires, and outer serving depend on the depth and sea-bed conditions in the locality of laying. For the deep sea cable, an armour of twenty-four wires will be used, of 0·086in diameter, each wire being protected by a coating of compound and an impregnated fabric tape. The overall diameter is 1·2in and the weight 62 cwt per n.m. in air or 36 cwt per n.m. in water. A telescoped sample of cable for intermediate depths is illustrated, with eighteen No. 8 (0·165in) wires ; in this case the overall diameter is 1·4in, weighing 112 cwt per n.m. in air or 80 cwt per n.m. in water. For shallow water still heavier armour is used, and possibly double armour for shore ends where a rocky bottom may be encountered.

Submerged repeaters have been developed to operate without attention over long periods under hydrostatic pressures of 3 tons per square inch. Power to operate the repeaters is supplied by a direct current through the inner conductor fed from the ends of the cables ; for the long crossing 2000V positive will be applied at one end and 2000V negative at the other. Special methods of locating faults and effecting repairs have also been developed.

For various reasons great accuracy is required in the manufacture of the cable. For example, the attenuation of 1950 n.m. of cable is approximately 900 and 3200 decibels at the lower and higher end, respectively, of the transmitted frequency band. The transmission level at any frequency must be maintained so as to avoid overloading repeaters at high levels or running into interference at low levels. Consequently the variation of attenuation with frequency must be accurately equalised at each repeater. Moreover, prediction is required at sea-bed conditions of temperature and pressure, as the cable characteristics depend appreciably on both these variables. Another consideration is that the deep sea repeaters do not include matching units, which means that their gain would be affected by irregularities of cable impedance due to reflections.

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Seam Welder Using Continuous Wire Electrode

OUR illustrations show two views of a 4kVA seam welder which is electronically controlled and is designed to use continuous wire electrode for welding very thin metal sheets at speeds of 2ft per minute. The machine, which was developed by the General Electric Company, Ltd., Magnet House, Kingsway, London, W.C.2, is said to be capable of welding two steel sheets, each about 0·010in thick, two Inconel or nickel sheets about 0·006in thick, or brass or copper sheets about 0·003in thick. The welds are of 1 cycle (1/50th second) duration, timed by an

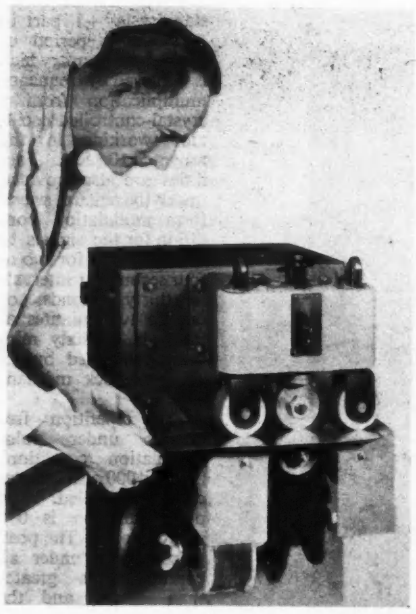


Fig. 1—Electronically Controlled Seam Welder Using Continuous Wire Electrode

electronic circuit using thyratron valves and triggered by a multivibrator circuit in which two gas-filled triodes are so coupled that they always fire in synchronism with the supply mains frequency. The welds can be spaced 2, 3 or 4 cycles apart to give forty-two, thirty-one or twenty-five welds an inch, respectively.

A characteristic of the machine is the use of a continuous wire electrode. Ordinary soft copper wire, 18 S.W.G., is passed continuously through a groove on the periphery of the bottom electrode disc (Fig. 1) so that it forms the electrode surface. This method of providing a continuous new electrode surface has obvious advantages over the use of a permanent electrode wheel which would need redressing and would decrease in diameter, thus presenting difficulties in matching its speed of rotation with that of the feed rollers.

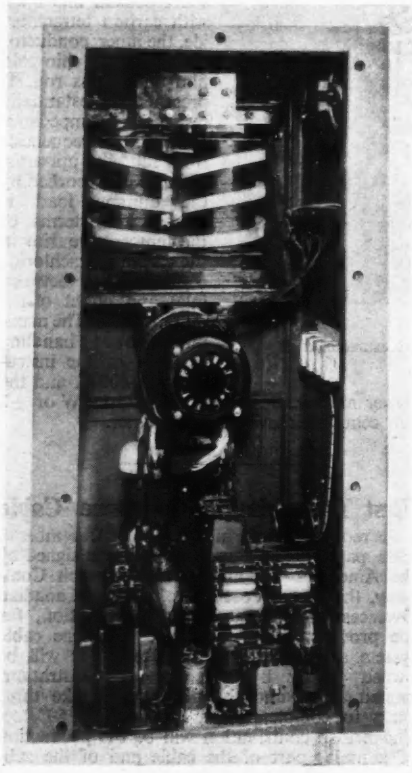


Fig. 2—Interior of Seam Welding Cabinet Showing Chassis Carrying Electronic Equipment

The wire is used direct from the reel (below the work table, Fig. 1) on which it is supplied. It passes via pulleys round the bottom electrode disc to a driven reel, also below the work-table, where it is taken up. The wire suffers only a slight burring during the welding operation and can be used afterwards for other purposes.

Both top and bottom electrode discs are of chrome copper. The bottom disc is driven from a fractional horsepower geared motor which also supplies the drive to the winding reel and to the lower of each of two pairs of guide rollers. These rollers, arranged before and after the electrodes, keep the work flat and the seam straight so that long, straight seams can be made. The pairs of rollers are slightly spring-loaded to grip the work. The rear or feed rollers have a slightly greater peripheral speed than the front rollers, and thus the work is kept taut between them. The upper rollers can be lifted clear of the work to allow curved seams to be made.

The seam welder is operated by means of a single rotary switch with three positions marked " off," " run," and " weld," to ensure that switching is carried out in the correct sequence, the motor being started before welding is begun and switched off only after the welding has been stopped. Welding current is infinitely variable by means of coarse and fine controls. Electrode pressure is variable from 20 lb to 100 lb per square inch. Graduated scales are provided to allow current and pressure settings to be recorded.

The machine has a welded steel cabinet with a gun metal casting to carry the mechanical unit. Sheets up to 14in wide can be accommodated. A separate casting carries the upper rollers and electrode system and this can be water cooled to remove heat from the upper electrode. The electronic timer is mounted on a separate chassis (Fig. 2) within the cabinet and is easily withdrawable. The seam welder is arranged to operate from a 400/440V, 50 c/s, single phase supply.

Rayon Project on Natal South Coast

INDUSTRIAL progress along the Natal South Coast is likely to receive some impetus when a £7,500,000 rayon factory at Umkomaas is completed. The project is sponsored by Courtaulds, Ltd., England ; the Industrial Development Corporation of South Africa, Ltd., and the Snia Viscosa, the Italian cellulose company.

The first batch of a total of 700 Italian technicians has already arrived in the town and another 250 are expected in June. These technicians will set up the factory plant and supervise the work.

The three concerns involved have formed the South African Industrial Cellulose Corporation (Pty.), Ltd., which, in turn, has three Zululand timber companies as subsidiaries, owning large areas of saligna gum plantations. These plantations will provide the wood which the Umkomaas factory will use to make cellulose pulp. At first the company plans to sell pulp only, but later developments may include the manufacture in South Africa of rayon products for which cellulose pulp is the base.

The factory will export about £4,000,000 worth of wood pulp every year when it goes into full production, and it will need 160,000 tons of timber per annum which will be converted into about 40,000 tons of wood pulp. The factory will draw 2,000,000 gallons of water per day from the Umkomaas River and the company has undertaken to supply Umkomaas township with up to 1,000,000 gallons of water daily. The site for the factory covers 100 acres and is about 2½ miles inland from the coast. When in production there will be employment for about 350 Europeans and about the same number of natives. Blue gum trees grow faster in Natal than in most other parts of the world, and it is for this reason that overseas manufacturers are interested in producing wood pulp for supplying their artificial silk factories with essential raw material.

Machining of Compressor Rotor Discs

The production of compressor discs for gas turbines presents several problems due to their thinness, profile and nature of the material. In this article details provided by Alfred Herbert, Ltd., Coventry, are given of a variant of one of its combination turret lathes which has been adapted so that both sides of the disc can be profiled simultaneously and the cutting loads balanced.

COMPLEX machining operations are encountered in the manufacture of several gas turbine components, of which turbine blading is the most familiar example. The profile of a representative item in this category is shown in Fig. 1, a compressor disc. These components are subject to the common compromise of obtaining maximum strength with minimum weight which together with the requirement for accurate dynamic balance and optimum standards of surface finish give rise to a number of production difficulties.

Under normal conditions when machining disc-form components, the inherent lack of rigidity gives rise to excessive vibrations with the resultant possibility of poor surface finish; deflection of the work under the cut reduces accurate facing to a trial and error basis, where even small errors can be expensive; and the unequal release of surface stresses caused by machining the faces successively can result in severe distortions which may not become apparent for some considerable time after the disc has been removed from the machine. Where the disc is profile-faced and is made of a material which work hardens readily, it will be appreciated that their efficient manufacture requires considerable planning skill and production "know-how."

Fig. 1—A Compressor Rotor Disc

Considerable experimental work has been carried out in the gas turbine and machine tool industry on this problem and we have recently obtained details from Alfred Herbert, Ltd., Coventry, of a variant of its No. 9B/30 combination turret lathe (Fig. 2) which has been fitted with special equipment. This equipment is based on the application of the technique of balanced contour turning. This method, which has proved highly successful in practice, consists simply of profiling both sides of the disc simultaneously so that the cutting conditions balance one another. Its success in operation is primarily dependent upon the exactitude with which the similarity of cutting conditions on opposite sides is maintained.

The machine is equipped with twin saddles, both of which are fitted with the standard longitudinal traversing mechanisms so that they can be adjusted independently along the bed. The cross sliding mechanism, however, is housed in the left-hand saddle only, the motion being transmitted to the right-hand cross slide by means of a rigid bar, which is carried by long bearing brackets attached to the front of each cross slide.

Each cutting tool is carried in a subsidiary slide mounted in the position normally occupied by the square turret as shown in Fig. 3. The contour turned by each tool is determined by a plate cam bolted to a large bracket carried on the saddle to one side of the tool slide. A hardened stylus carried in the side of each tool slide is maintained in contact with the cam by air pressure through a pneumatic cylinder carried in the base of each profiling tool slide.

The initial positioning of the tool in the tool slide is obtained by means of a setting gauge, the locating block for which can be clearly seen immediately below the tool nose in Fig. 3. For the purpose of taking successive cuts across the surface of the disc, the distance between the tool points can be varied by any amount up to ¼in by adjusting the axial positions of the stylus barrels within their respective tool slides. These adjustments can be effected in two ways; coarse adjustments are so made by means of the "Relief-Finish" levers which operate eccentric cams to move the stylus barrels in or out as desired, the amount of movement in intermediate positions being indicated by 0·010in graduations. Fine adjustments to the depths of cut for the finishing operations are obtained by rotating, in the appropriate direction, the micrometer dials carried on the end of each stylus barrel. When the required depth of cut has been applied, the "Relief-Finish" levers are locked in position by small finger-operated levers.

When loading the work the two saddles must be separated to permit access to the arbor, and also to prevent the possibility of damage to the component. Once the work is satisfac-

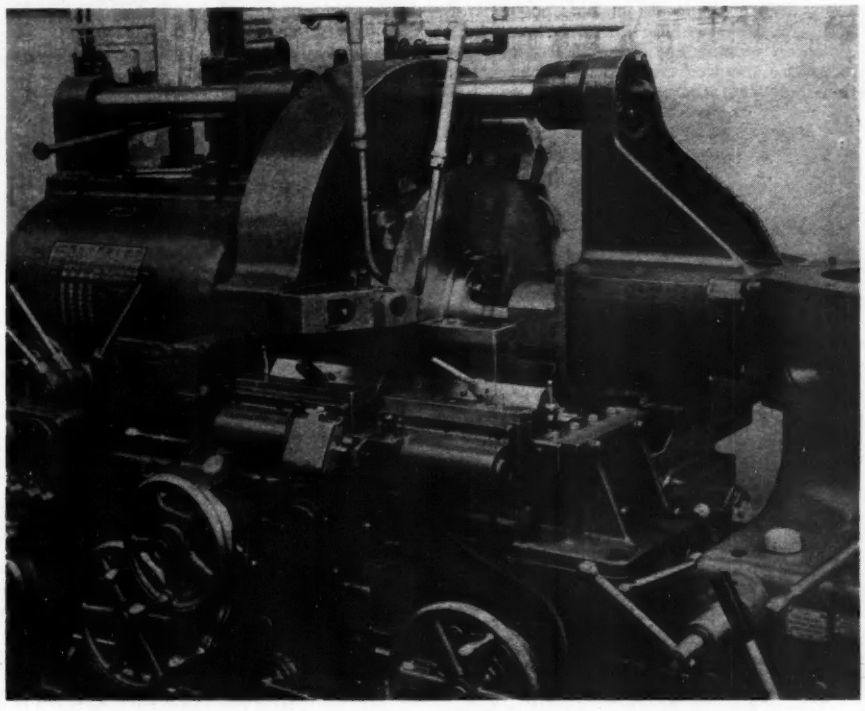


Fig. 2—Standard Combination Turret Lathe with Twin Saddles for Balanced Contour Turning

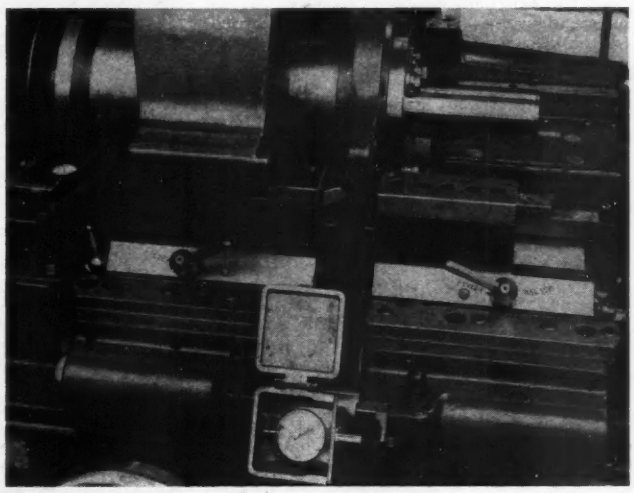


Fig. 3—Accurate Positioning of Both Tools Using Setting Gauge Mounted on the Work Holding Arbor

torily mounted, the saddles can be moved back to their precise original positions by reference to a pair of dial indicators carried at the front and side of the left-hand saddle. By this means the respective positions of both saddles can be accurately determined in relation to a datum pad mounted on the front face of the machine headstock. This operation is shown in Fig. 3 and requires the use of a simple setting gauge consisting of a cast iron ring, of the same thickness and bore dimensions as the compressor disc boss, having an integral arm carrying the tool setting piece—a tongue-like projection of the same thickness as the disc at its periphery minus the thickness of two 0·005in feeler gauges. After the tools have first been set to the correct positions in relation to their respective tool slides, the setting gauge is mounted on the work arbor and the saddles are then adjusted independently until the tool points contact the 0·005in feeler gauges. The dial indicators are then set at zero, thus enabling the finishing positions of the saddles to be repeated accurately.

The work locating and clamping arrangements are very simple, consisting of a heavy arbor bolted to the spindle flange having a additional support essential. In the profiling operation the normal facing procedure is reversed; by traversing outwards from the centre of the disc to the periphery the cut is applied with the work under tension and the danger of buckling the thin section is, by this method, considerably reduced.

One of the essential points of tool maintenance in this application is the necessity for considering the tools as a pair, giving them identical treatment at all times. When machining work-hardening materials keen cutting edges are essential and in this instance the desired degree of keenness is achieved by lapping the tools after regrinding, using a 400 grit diamond wheel. Nose radii are reduced to a minimum to keep the chip area small and to prevent glazing, this latter factor being undesirable because of the surface tension which usually accompanies polished finishes and the consequent danger of buckling or otherwise distorting the thin section.

A facility afforded on this machine is the control of the spindle speed which enables the cutting speed to be maintained at a constant figure throughout the total stroke of the cross slides. The speed control, the principle of which is shown in the diagram, Fig. 4, is effected by means of a plate cam *A* attached to the side of the left-hand cross slide. A pivoting spring-loaded follower *B* in contact with the cam surface is gradually depressed as the cross slide traverses from the centre of the work to the periphery, and the small rotary movement of the follower arm thus obtained is transmitted through a segment gear *C* and pinion *D* to a potentiometer *E* mounted behind the headstock. This acts in effect as a variable resistance which in conjunction with the control panel reduces the motor speed in proportion to the radial distance travelled by the cross slide.

All electrical controls, including a large tachometer dial registering the motor speed in revolutions per minute are centralised in a panel mounted above the feed box at the front of the machine. Provision is made for hand control of the motor speed through a separate potentiometer carried inside the control panel itself. Selection of the appropriate control, whether hand or cam-operated, is made by means of a rotary selector switch, which automatically renders the alternative system inoperative.

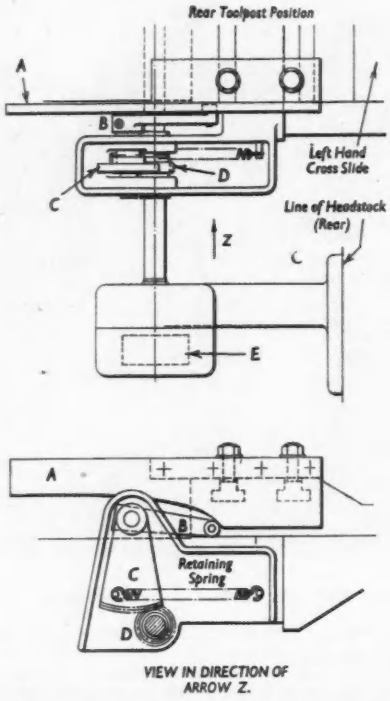


Fig. 4—Principle of Control of the Spindle Speed

pilot bar extension which is supported at its outer end by a needle roller bush ; this is carried on the hexagon turret in a special tool-holder which is in turn accurately aligned and supported by the standard overhead support bar. The semi-finished disc is located from the bore by a short spigot and clamped across the boss faces by means of a quick-release clamp plate fitted with pivoting " C "-washers.

In this example the disc is driven by friction, although for some classes of work, particularly where the boss diameter is small, it is necessary to introduce a service slot, for manufacturing purposes only, so that a more positive drive can be provided by means of a peg or key.

The illustrations show the first of these special machines to be built which include steady equipment that subsequent tests have shown to be superfluous on rimless disc work of this nature, but which are necessary for discs with rims.

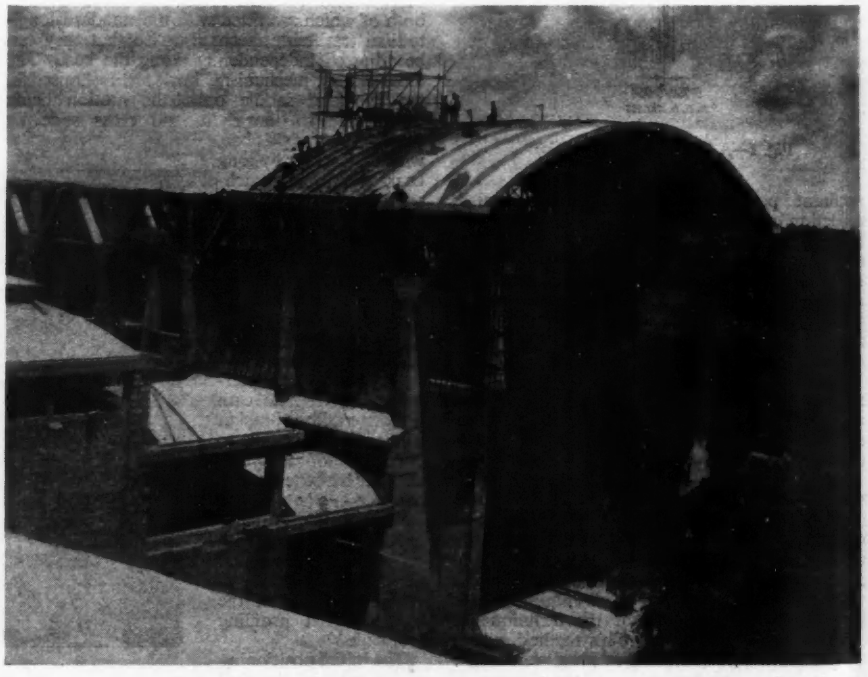
It has been found that the balanced cutting of the two main profiling tools eliminates all vibration and thus obviates the need for any additional means of support for the disc. This does not apply to rotor discs of the flange or rim form as the extra mass of metal on the periphery tends to amplify vibration and makes

Cement Factory at Bamburi, Kenya

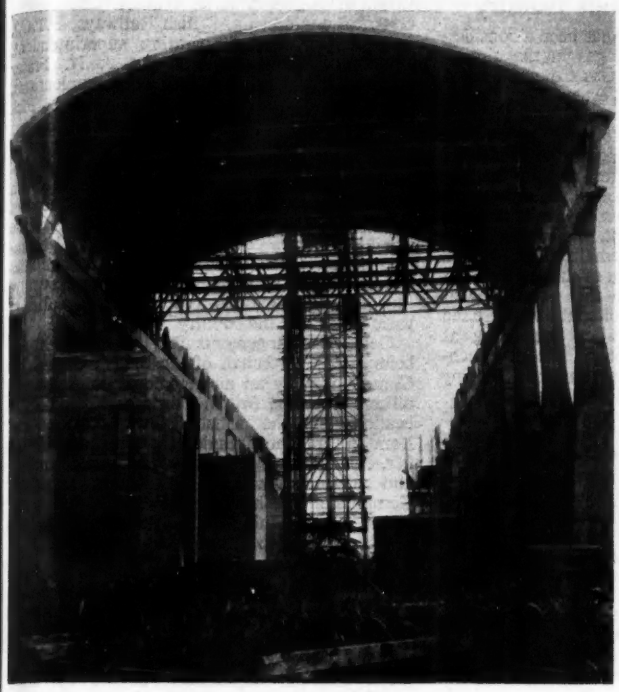
A CEMENT factory has been constructed for the British Standard Portland Cement Company, Ltd., at Bamburi, 6 miles north along the coast from Mombasa — Kenya's principal port—by Taylor Woodrow (East Africa), Ltd. Building was begun in April of last year and was completed in December. Early this year, this, the first complete cement factory in East Africa, will begin production, contributing 100,000 tons annually towards the growing appetite of the three territories of Kenya, Uganda and Tanganyika. Heavy plant and equipment from factories on the Rhine is now being installed.

The factory site covers 10 acres, and the factory comprises the following buildings : gantry crane hall, shale crushing plant, lime crushing plant, raw grinding mill, raw meal silos, kiln block, material storage bunkers, cement mill, bulk storage silos, packing plant, workshops, motor transport garage, and ancillary buildings. The whole work is of reinforced concrete construction. The photograph reproduced on this page shows the construction of the gantry crane hall. This building is 341ft 3in long and has an arched roof with a clear span of 86ft, the top of the arch being 80ft above the ground. The height of the arch from its springing is 15ft. The arch slab is only 2in. thick, with upstand beams of 1ft 2in. by 6in. section at 6ft 6in centres. Tension bars are incorporated in the construction at 8ft 9in centres.

It was decided to cast the roof in sections of 26ft 3in length and to construct a special kind of formwork that could be released by lever jacks, be travelled forward to the next section, and be then jacked up again to the required levels, ready for reinforcement and concrete to be placed. The arch formwork was supported on three W.O. lattice type steel trusses that spanned the complete width, and were carried on a steel frame bogie movable on the crane rails. The trusses were designed to carry the load without centre supports, but to check lateral whip and give increased stability



Gantry Crane Hall of Cement Factory, African Labour at Work on the Arch Roof



Gantry Crane Hall, Formwork for Roof

and also means of access, a centre support tower of tubular steel construction was erected under the centre of the trusses and this also was arranged to travel on rails, thus being mobile with the complete unit. It will be realised that to travel the formwork, provision had to be made to allow the tension bars to remain while the formwork proceeded. It was decided to make a longitudinal stool over the tension bars with packings between, so that as the formwork travelled forward, these packings could be quickly moved as necessary, thus giving freedom to the tension bars and maintaining the support of the superstructure above.

The main arch formwork was supported from the stoolings by tubular screw struts, braced with normal tubular scaffolding. Running transversely over the heads of the struts were 6in by 4in joists fabricated to the correct profile of the arch, and these formed the main support frames to carry 6in by 2in joists at 2ft 6in centres, decked out with 4in by 1in timber shuttering. At the springing points of the arch, specially made quadrant sections were fixed that could be easily taken out after concreting, thus giving clearance for lowering the formwork.

All concrete was vibrated by mechanical means and research and tests on cement and aggregates were made, to prove the most satisfactory mix of concrete for strength and workability. A number of concrete cubes were taken from each section of roof that was cast, and tested on site for compression strength. It was found that after 72 hours, with normal cement a compression strength of over 3000 lb per square inch was being obtained, sufficient to permit the tension bars to be stressed and formwork released and trundled forward to the next section.

A labour force of sixty Asians and nearly 300 Africans constructed the factory under the guidance of a mere handful of Europeans. In charge of the building work was Mr. A. E. Johnson, the site agent, assisted by Mr. B. Thomas (assistant engineer) and Messrs. G. Smith and R. Albon (assistant agents). Mr. S. Geleff, of Nairobi, with Mr. H. Spannring, of Vienna, acted as consulting engineer and was responsible for designing and planning the factory buildings. Mr. J. H. Spanton, who is the United Kingdom contracts manager of Taylor Woodrow, Ltd., visited the factory during its construction and advised on the building. He has given valued assistance in compiling this article.

Construction of Single Span Arch Roof of Gantry Crane Hall

Freight Marshalling Yard at Stratford, London

THE Eastern Region of British Railways recently received authority from the British Transport Commission to construct a new marshalling yard at Temple Mills, near Stratford, London, at a cost of £2,500,000. The new yard will replace a group of out-of-date yards and its introduction will result in an estimated net saving of £150,000 a year. The new yard will make possible a general speeding up of freight traffic between London, East Anglia, the Midlands and the North of England.

Temple Mills lies between two main junctions —Loughton Branch Junction and Lea Bridge Junction—and at present consists of ten yards. Six dependent yards at Goodmayes Up, Goodmayes Down, Thames Wharf, Beckton, Mile End and Northumberland Park lie within a 5 miles radius, and are largely doing work to relieve Temple Mills.

At Temple Mills there are now in operation nine flat and one hump yard, the flat yards having as a result of the design limitations of such yards, a capacity of only about 1000 wagons a day. In the yards almost every train, whether from east or west, conveys traffic for both forward and reverse directions and working at present is naturally complicated as the existing yards have been built up and added to as a matter of expediency. The uneconomic nature of the layout is illustrated by the fact that, whilst the total number of wagons moving into and out of the area is something less than 5000 a day, the total number of wagon shunting movements made in the sixteen yards is nearly 11,000. On average, each wagon has to be shunted twice. Six of the yards receive virtually no traffic on direct trains, being fed by transfers from other yards. An added complication exists in that large numbers of empty wagons, many of special kinds such as banana and meat vans, have to be held to meet the fluctuating demands arising in the London Docks.

Wagons are at present in constant movement between the main yards and the periphery yards and this is not only costly but results in wagons being detained for excessive periods. It has therefore been decided in the new layout to concentrate in one main distribution yard, supported by two reservoir yards, the work done by fifteen of the sixteen yards which at present exist. Of the old yards only Goodmayes down yard will remain.

The new Temple Mills yard will have twelve reception lines, six of which will be entered from either east or west. There will be fifty sorting sidings from twelve of which trains will be able to depart either east or west and all the proposed ten departure lines will enable trains to depart either east or west. Engine release lines, brake van storage lines, cattle pens and cripple repair lines will also be provided, together with a servicing depot for turning round locomotives.

On the south side of the yard and parallel with the sorting sidings will be five reception lines to be known as Manor Yard, and these lines will be used for through down trains to be re-engined, re-manned, or to attach or detach traffic. Allied to these reception sidings will be a miniature hump which will serve the southernmost twelve sorting sidings at the departure end of the main yard, in order to allow some secondary sorting of the express freight trains to Cambridge, Whitemoor and Norwich. Main passenger lines will be routed south of the new yard. Two reservoir yards to be provided will be known as East Yard and West Yard, and each will have a miniature hump.

The new yard at Temple Mills will have certain special factors all calculated to raise the speed of shunting. Beyond the crown of the main hump, for example, a release line is being provided to enable one humping engine to run clear so that a second train can be propelled from the reception sidings and humped without waiting. Special attention has been given also to the layout at the inlet to the reception lines to avoid the humping engines running round obstructing incoming trains.

Another important point in the new layout will be the design of the gradients and the provision for braking in two stages by

primary and secondary retarders. Advance in design in these respects is expected to reduce the unproductive time of the humping engines in closing down from over 30 per cent in the older mechanised yards to less than 10 per cent. The calculations on which this part of the design was based were set out in the paper read by Mr. R. E. Sadler before the Institution of Civil Engineers in May, 1953.

The work now to be put in hand will include new colour-light signalling, track circuiting and improved wagon repair facilities. Land will be used on which the present yards are situated and the new yard will be constructed while traffic continues to be handled. Construction of the new yard is expected to take four years.

Heat Exchangers for Internal Combustion Engines

On Tuesday, March 9th, a paper entitled "Heat Exchangers for Internal Combustion Engines" was read by Mr. H. E. Upton, before the Institute of Marine Engineers and is summarised below.

The paper discusses the three principal tubular heat exchangers in marine applications, namely, for engine coolants, lubricating oil and pressure charge air. Total heat available to heat transfer is stated to be largely independent of design and of the stroke/bore ratio, and it is noted that tests indicated that raising the jacket outlet temperature had decreased the fuel consumption, while a similar rise in the water temperature reduced the amount of heat transfer to the cylinder walls. Other tests showed that as the b.m.e.p. is increased the percentage of heat rejected to the coolant is decreased, and a table gives heat distribution, circulating rates and temperatures for engines grouped in three speed ranges.

Line drawings give examples of four water coolant systems as adopted for medium and high-speed engines; a Burmeister and Wain engine; a Sulzer engine and a Doxford engine; and each system is briefly outlined and followed by a note upon pressurised systems. The fresh water heat exchanger is next discussed and equations are given in the text which generally deal with questions relating to the variables governing the design of a heat exchanger such as the heat transfer performance and the overall heat transfer coefficient. A brief description of tubular liquid/liquid exchangers is accompanied by diagrams illustrating baffle arrangements for radial, segmental, guided and axial flows, and a table shows the effect of tube diameter on matrix density, and suitable pitch ratios are suggested for large and small units.

Water treatment and some guidance with regard to inhibitors are recorded before turning to oil cooling systems, the main design problems of which are broadly dealt with and curves are included showing the effect of cooling water flow on the overall heat transfer, and the reduction in performance of a piston oil cooler due to sludge formation. With regard to the stability of oil coolers, it is mentioned that in very cold conditions they are subject to what is known as coring, a phenomenon which occurs at a certain point and at which the temperature of the fluid being cooled continues to rise despite increased flow of the cooling fluid. Typical coring curves, having constant values, are shown plotted to a base of metal temperature, against mean oil temperature, and another graph illustrates the effect of parallel-path instability in the pressure loss variation across an oil cooler. Construction, materials and corrosion are next touched upon, and then the paper goes on to examine questions about the charge air cooler and, after noting certain established facts, gives as a general guide a graph showing the limiting lines of economical cooling of charge air for various compressor ratios related to cooling water and ambient air temperatures. Typical curves of thermal ratio for various flow arrangements in an air to water heat exchanger are included and the performance characteristics of a water-cooled pressure charge air cooler are also shown graphically. There are notes upon construction, operation and maintenance of heat exchangers, and a general discussion on self-actuating and wax-operated thermostats, remotely controlled self-acting valves and externally powered valves and their installation.

Gas and the Aircraft Industry

During recent years there has been a considerable increase in the use of gas in the aircraft industry, and last week the Gas Council in conjunction with the South Western Gas Board, arranged a press visit to the works of the Bristol Aeroplane Company, Ltd., to show some of the many ways in which a leading aircraft manufacturer uses gas. It is of interest to note that the engine division of this works requires some 270 million cubic feet of gas a year—about 80 per cent of the total consumption of the company and sufficient to meet the normal needs of a town the size of Taunton. In each of the departments visited during the tour of the works it was shown how very close control could be exercised with gas-fired equipment when processing at critical temperatures in some of the new techniques, such as precision casting and forging compressor blades of special alloy metals.

In addition to the familiar uses to which gas is put for heat treatment, metal melting and space heating in the engine division of the works, large quantities are consumed in processes such as stove enamelling, plating, degreasing, rust proofing, precision casting, forging, &c. As might be expected with the number and variety of components calling for heat treatment which go into a modern aircraft engine the heat treatment section is the largest consumer of gas and alone uses about 108 million cubic feet a year. The consumption in the machine shops is in the region of 49,500,000 cubic feet, in the foundries 44,500,000 cubic feet, and in the blade forging shop 16,000,000 cubic feet.

International Railway Congress

The International Railway Congress is to be held in London this year from May 19th to May 26th. The meetings will be held in Church House, Westminster, and it is stated that more than 450 delegates from thirty different countries will attend the seven business sessions and sectional discussions which have been arranged. The congress wil be formally opened by H.R.H. the Duke of Gloucester, the honorary president of the congress, supported by Mr. A. Lennox-Boyd, Minister of Transport and Civil Aviation; Monsieur de Vos, president of the International Railway Association and general manager of the Belgian National Railways; Sir Brian Robertson, chairman of the British Transport Commission; Sir John Benstead, deputy chairman of the British Transport Commission, and Sir John Elliott, chairman of the London Transport Executive.

During the course of the congress delegates will visit important railway centres in this country and inspect recent examples of technical development on British Railways and London Transport. The visits will include Willesden carriage cleaning and servicing depot; electrical control rooms and sub-stations on the Southern Region electrification; Swindon locomotive, carriage and wagon works; London Transport workshops and depots at Lillie Bridge and Acton; Southampton Docks; Liverpool Street-Shenfield electrification; the Central Line tube extension; Rugby locomotive testing station, and railway coastal protection works between Dover and Folkestone. There is also to be a special exhibition of British Railways and London Transport locomotives, rolling-stock, civil and signal engineering equipment at Willesden, and this exhibition will be open to the public from May 26th-29th.

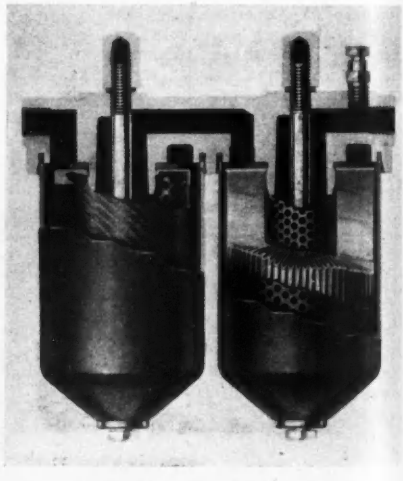
Subjects to be discussed at the International Railway Congress include maintenance of permanent way; modernisation of station buildings; methods of financing modernisation; a survey of electric traction systems with a view to deciding whether there are relevant reasons for preferring one system to another; methods of improving steam locomotive efficiency; radiophonic communications in railway working; staff recruitment; railway participation in road transport, and the protection of electric equipment. The five British officials who are among the reporters who have collated international data for consideration by the Congress are Dr. F. F. C. Curtis (Architect, British Railways, B.T.C.), Mr. S. B. Warder (chief officer, electrical engineering, British Railways, B.T.C.), Mr. S. G. Hearn (operating superintendent, London Midland Region), Mr. J. H. Fraser (chief officer, Signal and Telecommunications, British Railways, B.T.C.) and Mr. T. S. Pick (chief electrical engineer, London Transport Executive).

To provide delegates from overseas governments and railway administrations with an opportunity to inspect the latest products of British manufacturers, seven leading trade organisations in co-operation with the Federation of British Industries are offering facilities for congress delegates to visit any one of seventy-four different factories and industrial plants in various parts of the country.

Detailed arrangements for the congress are being made, on behalf of the British Organising Commission, by an arrangements committee of officers from the British Transport Commission headquarters, the British Railway Regions and London Transport, under the chairmanship of Mr. J. L. Harrington, the chief officer, marine and administration, of the British Transport Commission. The English general secretary is Mr. C. E. Whitworth. The congress is the first to be held in this country since 1925.

Two-Stage Fuel Filter

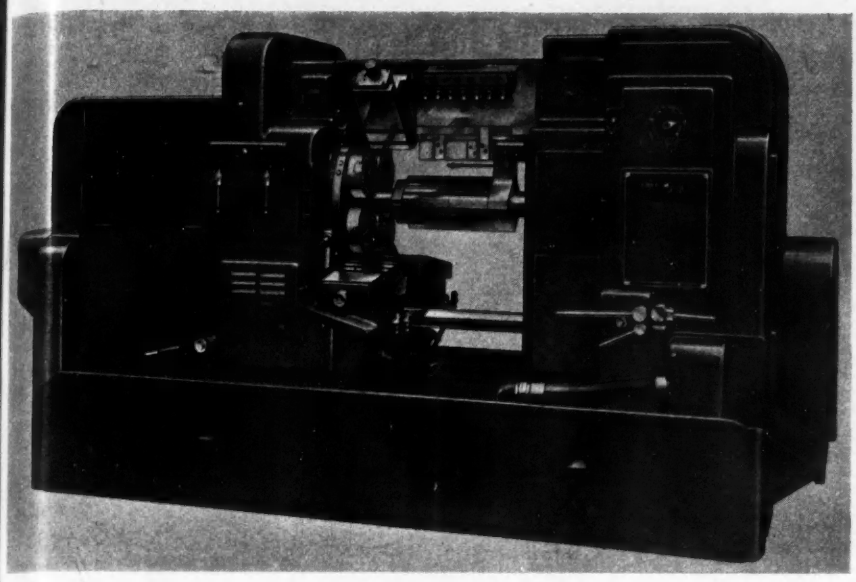
An essential requirement in the operation of high-speed diesel engines is a continuous supply of fuel free from impurities if a high standard of reliability is to be attained and freedom from troubles between overhauls ensured. Apart from causing stoppages and uneven running, contaminants in the fuel supply are also a source of damage to the reciprocating parts of high-precision injection equipment. To assist a supply of clean fuel, Automotive Products Company, Ltd., Leamington, has produced a new two-stage "Purolator" filter in which the primary and secondary filters are combined in one unit, thus effecting a saving in space and cost. The unit, of which we



Purolator "Micronic" Fuel Filter

give a cutaway view, consists of two filters joined by a common head. The fuel first passes through a primary "edge pattern" element, which removes the larger particles of foreign matter and then flows through a secondary plastic impregnated paper element, where the finest of the contaminants are trapped.

The primary stage metal element filter can be cleaned by a simple operation which can be carried out without disturbing the secondary filter, while the paper filter element of the second stage filter can be easily replaced, at small cost, when choked. The new unit is rated to have a nominal capacity of 4 gallons per hour and is expected to afford extra protection to the diesel engine.



Four-Spindle Chucking Automatic

Two Chucking Automatics

Two new large chucking automatics are now being made by Wickman, Ltd., Coventry, one with four and the other with six spindles. The four-spindle machine, illustrated above, has a 9in chuck capacity and the six-spindle machine a 7½in capacity. These machines were developed from the maker's four and six-spindle bar automatics, and in common with its other machines incorporate lever adjusting mechanisms for alteration of tool feed strokes without need for changing cams.

Each of the machines is driven by a 30 h.p. 960 r.p.m., foot-mounted motor on a hinged platform, through heavy matched vee belts. In the four-spindle machine the twenty-four spindle speeds available range from 29 to 473 r.p.m., and in the six-spindle machine from 51 to 675 r.p.m. The power, feed and speed ranges of the machines are designed to enable them to cover the widest field of use and take full advantage of carbide tooling.

The heat-treated forged steel spindles have large integral flanges for mounting chucks and run in precision taper and roller bearings. Each spindle is fitted with a large multi-plate clutch and brake operated by an individual fork. Air cylinders are used to operate the spindle clutches, brakes and chucks. These cylinders have a long drawbar stroke and each is provided with a combined running joint and valve of new design ; a simple reversing valve for external and internal gripping control, and a pressure safety switch which can be set to trip the feed if the air pressure falls below a safe limit.

The air cylinders are electrically controlled through light action levers, which are interlocked to prevent incorrect sequence. Under normal operating conditions with no tooling in the loading station the spindle is automatically stopped after completion of the indexing movement ready for unchucking of the machined workpiece. When accelerated end working tooling is used at the loading station, adjustable timing cams only stop the spindle automatically when the tools have retracted clear of the work.

The machines index anti-clockwise so that the heavier roughing operations on a workpiece are carried out at the lower station. Double indexing can be arranged on the six-spindle machine for loading to be carried out at stations 5 and 6 with individual controls at each station.

Cross slides with a 1¾in stroke are fitted as a standard in stations 1 and 2. If required, upper cross slides with a 2½in stroke can be fitted in stations 4 and 5 on the six-spindle machine, and stations 3 and 4 on the four-spindle machine. All cross slides have means of micrometer adjustment and are provided with a master stop engaging stop screws in the spindle drum.

The main tool block has a feed stroke of 5in and it is provided with a dead stop and step-by-step endwise adjustment, so that the position most favourable to the set-up can be used, dependent upon the length and swing of the work, stroke and tooling.

Independent upper end-working slides having a feed stroke of 5½in are also available for stations 3 and 4 on the four-spindle machine and stations 4 and 5 on the six-spindle machine. Standard toolholders available for a wide range of tools are, in many cases, interchangeable between stations on these machines, and other bar and chucking automatics made by the firm.

Attachments made for the new machines include units for high-speed drilling, independent reaming, plain threading with self-opening revolving diehead, or full threading with solid taps and dies.

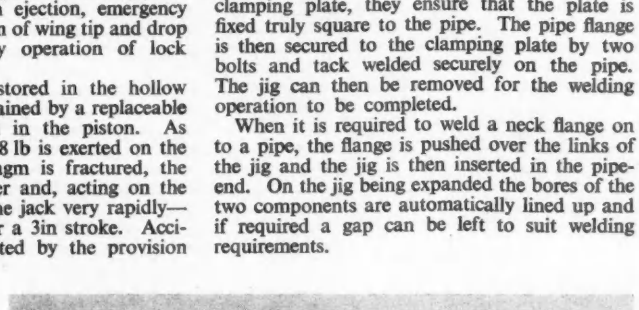
Emergency Pneumatic Actuators

AFTER considerable research into the problem of ensuring a completely reliable source of energy for all "one-shot" emergency duties in aircraft, the Hymatic Engineering Company, Ltd., of Redditch, Worcs, has now developed three sizes of lightweight, high-thrust, pneumatic snap-jacks, utilising air stored at 3000 lb per square inch. They are designed for such applications as canopy or hatch ejection, emergency cock operation, safe jettison of wing tip and drop tanks and the emergency operation of lock mechanisms.

Air under pressure is stored in the hollow spindle of the jack and retained by a replaceable metal diaphragm situated in the piston. As soon as a load of 6 lb to 8 lb is exerted on the operating pin the diaphragm is fractured, the air passes into the cylinder and, acting on the full piston area, extends the jack very rapidly—about one-third second for a 3in stroke. Accidental operation is prevented by the provision of a safety pin which is withdrawn after installation and charging or just before the take-off.

Among the many advantages offered by this self-contained emergeny actuator is the appreciable reduction in weight, as they are from four to ten times lighter than a spring providing the same stored energy. Moreover, there is no transport or storage problems as they may be charged with air after installation, and, if desired, a pressure gauge may be fitted so that replacements necessary at fixed intervals with other systems are avoided. The bulk, weight and complications of a conventional system employing a separate air bottle, selector valve, ram and attendant piping are also abolished and consequently the snap-jacks are unaffected by possible damage elsewhere in the aircraft.

The three models so far available, all operate within a temperature range of −40 deg. to +70 deg. Cent. The "RES6," utilising a stored energy of 2200ft-lb, develops an initial and final thrust of 9000 lb and 2280 lb respectively for a 6in stroke ; the "RES1," utilising 600ft-lb, develops thrusts of 4750 lb and 1250 lb for a 3in stroke, and the "RES2," 238ft-lb and thrusts of 3500 lb and 1000 lb for a stroke of 1·6in. The total weight of each is 3·5 lb, 2·6 lb and 0·9 lb respectively.

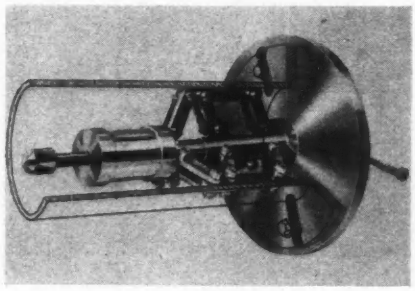


Actuator Giving Up to 9000 lb Initial Thrust for a Weight of 3·5 lb

Pipe Flange Welding Jig

A PHOTOGRAPH we reproduce below shows a new tool or welding jig which has been developed by Donald Ross and Partners, Ltd., 1–3, Arlington Road, London, N.W.1, to facilitate the welding of flanges squarely on to pipes. These jigs are made in five sizes suitable for pipes from 2in to 18in bore.

The construction of the jig and its method of application is fairly obvious. The flange ring is first pushed on the pipe and the body of the jig is inserted into the pipe bore until its clamping plate is correctly positioned in respect to the pipe end. When a tommy-bar—which can be seen projecting from behind the plate in our illustration—is then turned a system of links on the tool body open outwards to press firmly against the inside wall of the pipe. As these links are so designed that they are parallel in any position and always at right angles to the clamping plate, they ensure that the plate is fixed truly square to the pipe. The pipe flange is then secured to the clamping plate by two bolts and tack welded securely on the pipe. The jig can then be removed for the welding operation to be completed.



Welding Jig in Position on a Pipe with Flange Bolted to the Clamping Plate

When it is required to weld a neck flange on to a pipe, the flange is pushed over the links of the jig and the jig is then inserted in the pipe-end. On the jig being expanded the bores of the two components are automatically lined up and if required a gap can be left to suit welding requirements.

Indian Engineering News

(By Our Indian Correspondent)

Symposium on River Valley Projects

In the five-year plan there are eight projects costing Rs. 5 crores and more, sixteen projects costing between Rs. 1 crore, and Rs. 5 crores, twenty-one costing between Rs. 50 lakhs and Rs. 1 crore, twenty-seven costing between Rs. 5 lakhs and Rs. 50 lakhs, and the rest are minor projects, the total numbering 232 in all and accounting between them for almost a half of the total outlay on the Rs. 2069 crore plan. The Minister for Planning, who opened a recent symposium held under the auspices of the Central Board of Irrigation and Power in Delhi, said that this constituted a tremendous effort, considering the fact that the average yearly outlay was more than that during the preceding hundred years, and that not a single major project had been undertaken since 1930, a year that coincided with the general economic depression all over the world and marked political difficulties in India. Consequently, there was only a handful of senior engineers with experience of heavy construction, and even these had little opportunity during the intervening years to keep themselves abreast of modern trends in project construction and evaluation. The symposium which had the blessing of the United Nations Economic Commission for Asia and Far East was held with a view to pooling the information and experience gained during the last seven years and advising the Government in the formulation of a central, co-ordinated policy for the projects and their benefits.

A number of questions were discussed, the principal one being the "extent to which indirect gains and benefits to the community should be considered along with direct gains in assessing the productivity index of a particular river valley project." Most of the earlier projects were simple diversion weirs and barrages with low capital expenditure, and they were on the whole irrigation projects with greater tangible benefits to a predominantly agricultural community. The old yardstick therefore has become out-of-date, and in the absence of any similar cut-and-dry index (6 per cent return after ten years), the measurement of productivity has been a haphazard business. The matter has been further complicated by the fact that the indirect benefits which had been by and large ignored in the calculations must be included in any realistic appraisal of the value of a project and the general impression seemed to be that at the time of project planning cost-benefit studies should consider (1) long-range price levels for goods and services to be produced by the project; (2) value of labour, materials, supplies, taxes and interest rates; (3) prospective crop production, farm incomes and farm costs; and (4) benefits from recreational facilities, fisheries, wildlife preservation and forests. These benefits should be studied on the basis of a short term as well as a long-term policy. It appears that this is now becoming an accepted policy of the Government, for it has been reported that an economic report on the projected direct and indirect benefits from the Kosi project has been commissioned before its final evaluation and eventual sanction.

Another important question with strong political overtones, viz., "the criteria for fixing priorities between various projects from the local, regional and national aspects," received a thorough airing at the meeting. The general consensus seemed to be that "there is no better way of expression of priorities than through comparative benefit-cost analysis, the minimum requirement being that the benefit-to-cost ratio be at least unity." It was also agreed that selectivity should be aimed to a point where excess of benefits over costs should be a maximum as against the ratio of benefits-to-cost being a maximum. But in a country of India's magnitude and with unequally developed areas clamouring for development, the problem is as much economic as political. "In order to avoid unequal development in various parts of the country," said one participant, "there should be blending of projects having relatively high or low rate of financial return." This is also tied up with the fact that, despite a high benefit-to-cost ratio at one place as compared with another, a comparatively high capital cost of one project may complicate the question of selectivity. There appears to be an increasing tendency for rates for various jobs to be standardised throughout the country, particularly for such jobs as do not necessitate the import of special materials and machinery from distant places. The rate for masonry, for example, is fairly uniform, but the rate for earthwork and concrete is dependent upon the degree of mechanisation and in the case of cement the nearness or otherwise of cement factories. For Bhakra dam, for instance, the unit rate for mass concrete is Rs. 120 per 100 cubic feet (£9 per 100 cubic feet), while for Konar dam in the Damodar Valley, about 1200 miles away, the rate is almost double, viz., Rs. 243 per 100 cubic feet (£18 4s. 6d.). Such particular problems beyond the engineer's power can only be solved, according to a majority of the participants, including the Planning Minister, by "taking into confidence the people located in the vicinity of the project and by inviting their willing partnership."

Among other points raised mention may be made of the "role of experimental study and analysis through models and research in the planning, design and construction of large works." It was stated that experiments on models are always useful, instances being cited of (1) the alignment at Kakrapara weir near Bombay leading to a saving of Rs. 5 lakhs; and (2) fluming at Kotah barrage resulting in a saving of Rs. 30 lakhs. From 1933 to 1953 the saving due to hydraulic model investigations at the Central Water and Power Research Station at Poona was said to have amounted to an impressive figure of nearly 80 crores of rupees (£60,000,000).

The question of "foreign personnel" elicited some significant replies. The last word, endorsed by Mr. Nehru himself, was said by Mr. Handa: "In administrative and financial matters Indian engineers should be acting mainly on their own discretion and responsibility. Even in technical matters, final decisions should be taken by Indian engineers after obtaining the benefit of consultation with foreign experts, if warranted by the magnitude and importance of the problems. The technique and experience evolved on India's projects should not be discarded lightly with a view to imitating foreign procedures."

New Steel Plant

The Government of India has entered into an agreement with the German firms, Krupps and Demag, for the erection of a new steel plant with an initial capacity of 500,000 tons of ingots, to be increased eventually to 1,000,000 tons. The initial capital cost has been estimated at Rs. 72 crores (£54,000,000), of which the German combine is expected to provide Rs. 9·5 crores. The German investment will be for a period of ten years, with option to either side to continue the association for a further period of ten years. The exact amount of the German investment will depend on the value of the plant supplied by the combine. The combine will also be appointed as technical consultants and will receive a fixed fee of about Rs. 2·1 crores, which works out to about 3 per cent of the estimated cost. No royalties are payable and no bonus shares will be issued. The consultants will act as representatives of the company management during the erection stage of the plant. Global tenders for supplies will be invited and the Minister of Production has announced that "quality, prices and deliveries of plant will be the determining factors in selecting suppliers irrespective of their nationalities."

The Planning Commission has allotted a sum of Rs. 15 crores for the purpose and an approach is being made to the World Bank for a loan of about Rs. 20 crores. It is not yet clear how the rest of the capital will be secured. An offer of a loan of about £5,000,000 has been made by the U.K. Treasury towards the cost out of its capital subscription to the World Bank for the development of the Colombo plan countries, but details have yet to be worked out. The plant is expected to go into production four years after the preliminary details have been settled.

Labour Cost and Productivity at Tata Iron and Steel Company's Works, Jamshedpur

Year	Total saleable steel	Average annual income per employee	Average labour cost per ton	Average output of finished steel per employee
	Tons	Rs.	Rs.	Tons
1939–40 ...	777,000	768·41	31·54	24·36
1949–50 ...	727,000	1622·74	91·89	17·66
1950–51 ...	784,000	1851·81	94·47	19·60
1951–52 ...	799,000	2157·11	107·24	20·11
1952–53 ...	784,000	2206·53	110·84	19·91

Meanwhile, according to the report of the Tata Iron and Steel Company for the year ended March, 1953, the production at the company's mills in Jamshedpur has declined from 799,000 tons in 1951–52 to 784,000 tons, the first significant drop since 1948, when the figure was 664,000 tons. The average output of finished steel per employee, which has been rising steadily since 1949, has also dropped 0·2 ton, while the average labour cost per ton has increased by Rs. 3·6. These figures are to a considerable extent very representative of the general industrial situation and the table gives some significant statistics. The company's modernisation and development programme is, however, just under way and on its completion is expected to show better results.

Kosi River Project

The Government of India has appointed a six-man expert committee to scrutinise a blueprint for the Kosi project in Bihar, that has just been prepared by the Central Water and Power Commission. The expert committee, consisting of the chief engineers of Bihar, Madras, West Bengal and Bombay, the Chairman of the C.W.P.C., and a foreign adviser, Mr. Straub, of the U.S. Bureau of Reclamation, is expected to report on the project by the end of the year. The latest proposal put forward by the Power Commission envisages the construction of a barrage across the Kosi River at Hanuman Nagar, on the Bihar-Nepal border, and the training of the river along a given channel below this point by confining it within two 70-mile long embankments. The cost is estimated at Rs. 40 crores (£30,000,000).

The project will help stop the westward drift of the river and also to a great extent control the flood waters which every year inundate the countryside, destroy crops and villages and cause considerable loss of life and property, which this year alone has been estimated at over a million pounds. The embankments, together with the diversion of 50,000 cusecs from the main stream into an old channel of the river, will moderate floods, and the barrage will provide coarse silt control and irrigation benefits from a canal on the left bank. Work on the project is expected to commence early next year and will take about six years to complete. But the embankments, which are needed urgently for flood control, are likely to be ready within half that time. A comprehensive project with a series of dams and barrages along the river, is also being prepared, but it is most unlikely that the ambitious scheme involving an outlay of over £150 million will be undertaken at this stage. The river is one of the major rivers of North-East India and its hydro-electric and irrigation potential is at least as large as that of the Mahanadi in Orissa and the Sutlej at Bhakra.

Technical Report

Flameproof Electrical Apparatus: Flanged Joints 1in in Radial Breadth, in Mixtures of Ethyl Ether Vapour and Air (Ref. G/T280). By T. J. A. Brown and N. Simpson. The British Electrical and Allied Industries Research Association, Dorking Road, Leatherhead, Surrey. Price 7s. 6d., postage 3d.—For explosive mixtures of ethyl ether vapour and air, ignited in a bronze sphere having horizontal equatorial flanges 1in in radial breadth, the most incendive internal mixture is that containing 4·0 per cent of ether vapour by volume; the most readily ignitible external mixture contains 3·0 per cent of ether vapour by volume. For this combination of internal and external mixtures, the maximum experimental safe gap (M.E.S.G.), on a criterion of $n=20$, $k=0·001$in, is 0·033in, and the statistical maximum safe gap (reassessed) (S.M.S.G.) (R.) is 0·024(7)in.

The experimental and statistical safe gaps obtained with flanges ¼in in radial breadth are given in report Ref. G/T277; a comparison of the results given in that report with those now presented shows that as a result of the reduction in flange breadth from 1in to ¼in, the M.E.S.G. is reduced from 0·033in to 0·029in, i.e. by 12 per cent; and the S.M.S.G. (R) from 0·024(7)in to 0·020in, i.e. by 20 per cent.

Industrial and Labour Notes

Engineering and Shipbuilding Wages

At a delegate conference of the unions comprising the Confederation of Shipbuilding and Engineering Unions, which was held in London on Wednesday of last week, it was decided to seek new meetings with the employers' federations on the wages claims. The Engineering and Allied Employers National Federation and the Shipbuilding Employers Federation had already indicated that they were willing to offer a 5 per cent wage increase, as suggested by the Courts of Inquiry, but this offer has not so far been acceptable to the union representatives.

At the end of last week, the Engineering and Allied Employers National Federation informed the Confederation of Shipbuilding and Engineering Unions that it was agreeable to another meeting. But the Federation stated that it could not make any increase on the offer of 5 per cent. It again pointed out that it was not able to accept the original 15 per cent claim " in whole or part " because it felt that the decline in orders and the competitive position in overseas markets, which had been steadily worsening, did not permit of any advance in wages and prices.

The meeting between the engineering employers' representatives and the unions was held on Wednesday, and a similar meeting between the unions and the shipbuilding employers was arranged to be held yesterday.

Earnings and Hours

Last October, the Ministry of Labour conducted one of its periodic inquiries into the average weekly earnings and working hours of manual wage-earners employed in manufacturing industries generally and in some of the principal non-manufacturing industries in the United Kingdom. The particulars collected related to the last pay week of October, 1953, and approximately 63,000 establishments provided information.

The results of this inquiry have now been published in the *Ministry of Labour Gazette*. They show that in the last pay week of October the average earnings, in all the manufacturing industries considered, were: men, £9 16s. 7d.; youths and boys, £3 17s. 1d.; women, £5 3s. 2d.; and girls, £3 5s. 4d. If the principal non-manufacturing industries are considered with the manufacturing industries then the average earnings were : men, £9 9s. 2d.; youths and boys, £3 18s. 11d.; women, £5 2s. 5d.; and girls, £3 4s. 11d. the percentage increases, compared with October, 1938, being respectively 174, 203, 215 and 251 per cent. The figures given in the Ministry's survey show that the average earnings, in the last pay week of October, in the industries classified as " engineering, shipbuilding and electrical goods," were : men, £9 18s. 7d.; youths and boys, £3 14s. 4d.; women, £5 8s. 11d.; and girls, £3 8s. 5d., the average hours worked being : men, 48·2 ; youths and boys, 44 ; women, 42·7 ; and girls, 42·7. In all the industries coming within the scope of the survey the average hours worked in the last week of October were : men, 47·9 ; youths and boys, 44·6 ; women, 42 ; and girls, 42·8.

The Ministry of Labour says that there have been increases in the rates of wages in a number of industries since this inquiry was made. It is estimated that the effect of increases known to have been made up to and including February of this year has been to raise the general level of full-time weekly wage rates in the industries covered by the inquiry by about 1 per cent.

Changes in Wage Rates

Changes in wage rates which were reported to the Ministry of Labour as becoming effective in February in the United Kingdom resulted in an aggregate increase of approximately £452,000 in the weekly full-time wages of about 1,980,000 workpeople. The principal increases affected workpeople in building and civil engineering contracting, coal mining and the railway service. Others receiving increases were those employed in heating, ventilating and domestic engineering.

In building and civil engineering contracting, sliding scale arrangements based on the index of retail prices gave an increase of a penny an hour to adult workers. In coal mining there was an increase, payable retrospectively from the middle of January, of 8s. 6d. a week in the national minimum wage for adult male underground workers, and of 7s. 6d. for adult male surface workers ; shift rates for adult workers were increased by 1s. 5d. a shift underground and 1s. 3d. on the surface. On British Railways there was an increase payable in January of 6 per cent on the wage rates operative prior to December 6, 1953, the percentage increase including the flat rate advances already paid as from that date. In heating, ventilating and domestic engineering, craftsmen and adult mates received an increase of one penny an hour.

The Ministry of Labour says that in the first two months of this year changes in wage rates resulted in increases aggregating £619,300 a week in the wages of approximately 2,703,000 workers. In the corresponding months of last year there was an increase of £698,000 in the weekly full-time wages of 2,403,000 workpeople. The index of rates of wages (June 30, 1947=100) stood at 139 for all workers at the end of February, which was one point higher than at the end of last year.

Iron Castings

The Council of Ironfoundry Associations has stated that last year the total production of iron castings in the United Kingdom was 3,638,000 tons, which included 3,504,000 tons of grey and high-duty iron castings and 134,000 tons of malleable iron castings. The total was 3·2 per cent lower than the record output reached in 1952, but, the Council says, there were welcome signs of a strong movement towards recovery in the final quarter of last year. When last year's total output is broken down among the six main sections of the foundry industry, it is shown that there was a drop in automobile and engineering and jobbing castings. In the latter section, 39·3 per cent of the total output of iron castings was taken up last year, which was 14 per cent below the quantity required in 1952. This decline, the Council suggests, reflected the temporary setbacks in many branches of the engineering industry. On the other hand, the proportion of iron castings for building and domestic purposes—15·1 per cent of the total production—was a record.

At the annual meeting of the Council of Ironfoundry Associations, which was held last week, Mr. N. P. Newman was re-elected chairman, and Mr. Leonard Gould, Mr. F. D. Ley and Mr. H. V. Shelton were re-elected vice-chairmen.

Engineering Industry's Capacity and Deliveries

A survey of the trend of United Kingdom exports during 1953 has been made recently by Government officials and some of the information collected in connection with it has now been published in the *Board of Trade Journal*. In general, the survey has revealed that there was a marked increase in the level of world industrial activity between the second half of 1952 and the first half of 1953, but, it is stated, apart from American military aid shipments, there was very little increase in world trade.

Dealing with some of the internal factors affecting United Kingdom exports, the survey says that the volume of orders on hand in the engineering industries was falling continuously from the spring of 1952 into the autumn of 1953. Towards the end of that period, however, there was some recovery in the volume of new orders received both for home and export, but the rate of new orders is still below the current level of output. The reduction in demand and the increase in steel supplies, it is remarked, have led to a general improvement in deliveries of capital goods, and over most of the field of engineering exports delivery can be made broadly within the time required for manufacture, while standard items are increasingly available from stock. But, the survey continues, in some of the heavier capital goods industries supply difficulties are still being experienced, and in particular instances engineering exports may be impeded by shortages of skilled labour or of materials or basic components such as steel plate and forgings. Generally speaking, however, the survey has indicated that the direct pressure of defence and home investment demand on the engineering industries no longer appears to be excessive.

At the same time, it is pointed out that if there were to be a rapid revival of world demand for capital goods some further growth in capacity would be needed. Capital goods have accounted for an increasing share of world trade in manufactures over the past fifty years and, the survey comments, the prospects are that we shall have to rely partly on larger sales of these goods for any substantial increase in our exports. They already represent, it is stated, a higher proportion of the exports of this country's chief competitors, the U.S.A. and Germany, than of its own exports. The survey adds that future demand for the United Kingdom's exports will depend partly on the level of world demand as a whole, but it will depend also on what British industry does to increase its productivity and reduce its costs so that it can offer prices, delivery dates and other terms which will attract demand to this country in preference to others.

Industrial Investment and Efficiency

In a speech to the National Union of Manufacturers, on Thursday of last week, the Minister of State, Board of Trade, Mr. D. Heathcoat Amory, made a reference to investment in British industry. He said that if this country was to be ahead of its competitors its factories must clearly have the most modern equipment obtainable. Productivity was increasing, but it must be remembered that output per operative here was still less than half what it was in the U.S.A.

Much faster progress in productivity and a much higher rate of investment in industry were needed, Mr. Heathcoat Amory emphasised, or this country would be left behind. The Government, he added, entirely agreed that industrial and personal savings must be encouraged and that the present burden of taxation was too heavy. The difficulty that had to be grappled with daily was how to reduce Government expenditure with the present commitments for defence, and in so many other directions. But, however it was looked at, Mr. Heathcoat Amory concluded, the key to success was in the highest possible efficiency for British industry. This country must get and keep a lap ahead of any of its competitors.

Regional Boards for Industry

The Chancellor of the Exchequer recently set up a committee, under the chairmanship of Sir Horace Hamilton, to review the present functions of the Regional Boards for Industry. This committee included representatives of Government departments and of the boards themselves. It will be recalled that the Regional Boards were first established in 1940 to encourage and assist the maximum effort for war production. They have been maintained subsequently to deal with post-war industrial problems.

It has been announced this week that the Chancellor of the Exchequer has accepted the findings of Sir Horace Hamilton's committee, and has decided that the eleven Regional Boards, covering all areas of Great Britain, shall continue to deal with all aspects of productive industry apart from wages and conditions of employment. The committee was unanimous in the view that these boards could continue to make a valuable contribution to the industrial life of the country. Furthermore, the committee recommended that steps might be taken to bring the advantages of the Regional Boards' machinery to the notice of Government departments and industrial organisations in order that that machinery might be more extensively used than it is at present.

Notes and Memoranda

Rail and Road

STUDY OF TRAFFIC ENGINEERING PROBLEMS.—The International Road Federation has announced that, under the auspices of the Organisation for European Economic Co-operation, a party of thirty-two officials representing eleven European countries, is visiting the U.S.A. to study traffic engineering problems. The tour will occupy about two months and the American cities which are to be visited have been selected on the ground of their resemblance, both climatically and geographically, to European cities.

NEW TRACKS FOR BRITISH RAILWAYS.—British Railways plan to carry out 1821 miles of complete and partial renewals of track during 1954. Standard flat-bottom rails will be used for 923 miles of new track and bull-head rails for 449 miles, the remainder being partial renewals such as resleepering. The materials needed include 250,000 tons of steel rails, 3,500,000 sleepers and 2,000,000 cubic feet of crossing timbers. In addition 9000 tons of steel will be used to renew 74 miles of conductor rails on electrified lines. The renewal programmes also include 136 bridges, 45 miles of new drains, and 244 miles of fencing and other lineside structures as well as signalling and telecommunication equipment.

Air and Water

CABLE SHIP "RECORDER."—We are informed by Cable and Wireless, Ltd., that the cable ship "Recorder," of 3300 tons, which is under construction for the company at the Neptune yard of Swan, Hunter and Wigham Richardson, Ltd., will be launched on May 3rd. When completed the ship will be stationed at Singapore to maintain sections of the cable system in the Indian and Pacific Oceans.

OIL ENGINE WALL CHARTS.—We are informed by Davey Paxman and Co., Ltd., that, to show details of the modernised "R.P.H. II" engines, which are manufactured in six sizes from 165 to 833 b.h.p., the company has produced a large-scale exploded view in half-tone form of the twelve cylinder model. This chart, which measures 30in by 40in, may be obtained free from the firm.

HEYSHAM-BELFAST SERVICE.—The three new cross-channel ships at present under construction at the yards of William Denny and Brothers, Ltd., and Harland and Wolff, Ltd., for the Heysham-Belfast service of British Railways (London Midland Region) will each carry 1800 passengers. The ships, which will be fitted with stabilisers and driven by turbine machinery, will replace the three "Dukes" which have served the route for twenty-five years.

EXPERIMENTAL HELICOPTER WITH SEPARATE THRUST AND LIFT PROPELLERS.—The Fairey Aviation Company announces that the Fairey "Gyrodyne" research helicopter has completed initial flight tests. It is the first British helicopter to fly with the rotor driven by tip jets and it has also the largest metal blade rotor. The Fairey Company in conjunction with the helicopter branch of the Ministry of Supply, has converted the "Gyrodyne" from its original mechanically driven rotor form to the present configuration. This conversion has been undertaken to test under practical conditions some of the problems associated with tip jet propulsion for helicopters. It is not destined to become a production aircraft. The "Gyrodyne" is powered by an Alvis "Leonides" piston engine and has a two-bladed rotor. As already described in THE ENGINEER, January, 8, 1954, engine power is used to drive compressors which supply compressed air through hollow rotor blades to tip pressure jets, of Fairey design. In cruising flight the major part of the engine power is transferred to two pusher propellers.

Miscellanea

IRON AND STEEL BOARD'S FINANCIAL YEAR.—The Minister of Supply has made an Order under the Iron and Steel Act, 1953, prescribing December 31st as the date on which the Iron and Steel Board's financial year shall end and providing that the Board's first financial year shall be the period from July 13, 1953, to December 31, 1954.

TUNGSTEN ORE PRICES.—After several reductions recently in the selling prices for tungsten ores, the Ministry of Materials has now announced an increase, operating from March 26th. The revised prices of ores of standard 65 per cent grade and ordinary quality are: wolframite, £6 10s., and scheelite, £6 5s. per long ton, delivered to consumers' works.

DIRECTORATE OF NON-FERROUS METALS.—The Ministry of Materials has announced that from April 23rd the remaining duties of the Directorate of Non-Ferrous Metals at Rugby will be taken over by the headquarters of the Ministry of Materials, Horse Guards Avenue, London, S.W.1, and correspondence should be addressed accordingly. Mr. R. F. Rucker, the present director, will retire from the public service at the end of April.

STEEL PLATE PRODUCTION.—In reply to a Parliamentary question last Monday, the Minister of Supply, Mr. Duncan Sandys, said that steel plate making capacity in this country was being steadily expanded. Production last year was about 200,000 tons more than in 1952, and a further increase in output of about 100,000 tons was expected this year. Developments in the steel industry should lead to still further increases in 1955 and 1956. A substantial part of the increased production, the Minister stated, would be directed towards shipbuilding.

ENGINEER BUYERS AND REPRESENTATIVES ASSOCIATION.—The Engineer Buyers and Representatives Association has now published the second edition of its *Guide and List of Members*, which contains the names and firms of some 300 new members. The guide includes in its pages standing orders and rules of procedure, branch rules, by-laws and regulations, subscription rates, and entrance fees. The address of the Association is 47, Victoria Street, London, S.W.1.

ELECTRICITY GENERATING PLANT.—The Parliamentary Secretary to the Ministry of Fuel and Power, Mr. Joynson-Hicks, stated in Parliament a few days ago that developments in the electricity supply industry envisaged the commissioning of about 17,000MW of new high-efficiency plant in the next ten years, costing over £1000 million at present prices. Reduction in the output from old plant would depend upon the increase in demand for electricity, and the saving in fuel consumption could not, therefore, be estimated.

PEAKE MEDAL AWARD.—At a meeting of the Midland Institute of Mining Engineers, which was held at Doncaster yesterday, the Peake medal was presented to Major T. W. Adam, managing director of the Monckton Coke and Chemical Company, Ltd. The medal is awarded for distinguished service to mining engineering, and since its inception in 1917 only four presentations have been made. Major Adam has just retired from the secretaryship of the Midland Institute of Mining Engineers, after thirty-four years in that office.

RETIREMENT OF MR. M. BURNINGHAM.—This week, Mr. Montague Burningham has retired from the position of joint managing director of Keith Blackman, Ltd., Mill Mead Road, London, N.17. He will continue to serve as chairman of the company. Mr. Burningham has completed nearly fifty-eight years with Keith Blackman, Ltd. He was appointed secretary of the company in 1926, joined the board in 1929, and was elected chairman and managing director in 1945. Early in 1952 Mr. D. S. Woodley was appointed a joint managing director in addition to his post as technical manager. He has now become sole managing director of the firm.

INSIGNIA AWARD IN TECHNOLOGY.—In our issue of December 25, 1953, we recorded the procedure which has been adopted by the City and Guilds of London Institute for making the Insignia Award in Technology which it established at the end of 1952. Candidates upon whom the award is conferred receive a warrant specifying the section of industry and the branch of technology in which their knowledge and skill are recognised. Recently, an announcement has been made that the award has been conferred on Mr. A. A. Daultrey for competence in production engineering; Mr. E. Ryalls, in respect of welding technology, and Mr. T. Hurst for his ability in the field of foundry technology. Each of these candidates submitted a thesis on the subject of their particular work. In addition, the Institute has made annual awards to "suitable recipients in respect of each of the five main industrial groups." Those awards are as follows: Dr. Horace W. Clarke, chemical industries; Mr. J. Batty, constructional industries; Mr. E. H. Jolley, electrical industries; Mr. S. H. Russell, mechanical industries, and Mr. T. R. Barrow, textile industries.

MR. HUBERT GREENWELL'S RETIREMENT.—Last week it was announced that Mr. Hubert Greenwell had retired after fifty-four years in technical journalism with our contemporary, *The Colliery Guardian*. Mr. Greenwell, who is seventy-six, was born in North Shields and served an apprenticeship in the mining industry under his grandfather, who was a mining engineer. Hubert Greenwell was on the editorial staff of the *Newcastle Daily Chronicle* for two years after leaving the mining industry, and early in 1900 he joined his uncle, Alan Greenwell, in London, on *The Colliery Guardian*. He succeeded his uncle as editor of that journal in 1912, in which position he continued until 1935, when illness compelled him to share some of his responsibilities. He has continued since to serve the paper as joint editor. In addition to his work for *The Colliery Guardian*, Mr. Greenwell edited *The Colliery Manager's Pocket Book* and is also the author of a booklet dealing with the Minimum Wages Act. He is a member of the North of England Institute of Mining and Mechanical Engineers and the South Wales Institute of Engineers, and a Fellow of the Royal Statistical Society.

FOSTER TRANSFORMERS, LTD., JUBILEE.—We have received a brochure published by Foster Transformers, Ltd., South Wimbledon, to mark the firm's fiftieth anniversary. The company's manufacturing interests began with lighting equipment and it was in 1903 that the first Foster hot-wire arc lamp was made in a small workshop in Worple Road, Wimbledon. Five years later the company took over the Brockie Pell arc lamp. Soon afterwards it began making metal filament vacuum lamps with auto-transformers and in 1910 new works were established on the present site in South Wimbledon. It was then that the development and manufacture of transformers became one of the company's main interests. In 1937 the firm became associated with the Lancashire Dynamo group of companies and in 1951, in the interests of specialisation, within the group, the manufacture of Foster "H.I." switchgear was transferred to a new associate company, Lancashire Dynamo Switchgear, Ltd. Since then all the resources of Foster Transformers, Ltd., have been concerned with equipment for the transformation, regulation and control of power supply for industry. The firm's research and development facilities include a high-voltage laboratory equipped with a 500kV Marx impulse generator and a 300kV testing transformer with up-to-date measuring and recording apparatus.

IRON AND STEEL INSTITUTE.—The iron and steel engineers' group of the Iron and Steel Institute is arranging for a meeting of junior engineers to be held at Buxton from Monday to Thursday, April 26th to 29th. Its object is to provide an opportunity for the younger engineers and operators (those below the age of thirty-five) in the iron and steel and associated industries to discuss engineering problems and visit works. Four papers are to be presented for discussion in the afternoon and evening of Monday, April 26th, at St. Ann's Hotel, Buxton. They are: "The Starting Up of an Automatic Repeating Hoop Mill," by Mr. D. W. Ainsbury; "The Installation and Commissioning of the Electrical Equipment associated with a Bessemer Converter Plant," by Mr. J. S. Reed; "The Erection and Commissioning of a Large Combined Ingot Stripping, Charging and Drawing Crane," by Mr. W. D. B. Glass, and "The Commissioning of a Reheating Furnace," by Mr. B. L. Nixon and Mr. A. Hunter. Visits to steel works are planned for Tuesday and Wednesday, April 27th and 28th, and the meeting will conclude on Thursday morning, April 29th, with a lecture on "The Iron and Steel Industry in the U.S.A."

USE OF SYNTHETIC DETERGENTS.—The committee appointed by Mr. Harold Macmillan, Minister of Housing and Local Government, in May last year, to examine and report on the effects of the increasing use of synthetic detergents, has presented an interim report which has now been published. The committee says complex problems are involved and it may be a year or more before it can report fully. The available evidence, it states, does not justify any immediate alarm, although careful examination is needed of the effects of synthetic detergents on sewage treatment, the condition of rivers and the purity of water supplies. The committee point out that both synthetic detergents and soap powders can cause dermatitis in certain cases, but there has been no significant increase in the incidence of this complaint since synthetic detergents came into common use. The committee thinks that the excellent grease-removing properties of synthetic detergents may accentuate the need to avoid the use of easily corroded metals in plumbing equipment, but it finds that no general corrosion problem has arisen so far. The most serious problems, in the committee's view, are in connection with sewage treatment, particularly where the resulting effluents are discharged to rivers used for public water supply. It mentions foam nuisance at some sewage works, the possibility of reduced purification and, hence, worsened effluents, and the question of the effect on rivers of the synthetic detergents which still remain in sewage effluents after treatment. Investigations into all these matters are in hand. The report is entitled "Interim Report of the Committee on Synthetic Detergents," and it is published by H.M. Stationery Office, price 4d.

Personal and Business

MR. S. Z. DE FERRANTI has been elected a director of Ferranti, Ltd., Hollinwood, Lancs.

MR. H. BAINBRIDGE has been elected a director of Chatwood Safe and Engineering Co., Ltd., Shrewsbury.

MR. E. J. HAGUE, manager of THE ENGINEER, has been appointed a director of Morgan Brothers (Publishers), Ltd.

MR. H. P. WHITE has been appointed head of the data and publications section of the technical service department of Mullard, Ltd.

THE BRUSH ELECTRICAL ENGINEERING COMPANY, Ltd., announces the appointment of Mr. Maurice Tattersfield as deputy general manager of the Loughborough Works.

MR. W. M. BENNETT, A.M.I.E.E., has been taken into partnership by Messrs. Mackness and Shipley, consulting engineers, Parliament Mansions, Abbey Orchard Street, London, S.W.1.

GEORGE SALTER AND CO., Ltd., West Bromwich, states that Mr. G. Rushton, sales manager of its roller bearing division, has been appointed, in addition, sales manager of the retaining ring division.

SCOTTISH OILS, Ltd., announces the retirement of Mr. Robert Crichton from the post of managing director, after fifty-eight years in the oil industry, and the appointment of Mr. J. M. Caldwell as his successor.

DALLOW LAMBERT AND CO., Ltd., Leicester, announces the retirement of Mr. R. E. Haylock, manager of its London office for the last thirty-three years. Mr. A. P. Reeve has succeeded him at the London office at 20, Fitzroy Square, W.1.

HENRY WIGGIN AND CO., Ltd., Birmingham, states that Mr. J. O. Hitchcock will relinquish his position as assistant managing director on May 1st to become assistant to the chairman of the Mond Nickel Company, Ltd. He will continue as a director of Henry Wiggin and Co., Ltd. Mr. H. W. G. Hignett, superintendent of the Mond Nickel Company's development and research laboratory, has been appointed to the board of Henry Wiggin and Co., Ltd., and will take charge of technical (metallurgical) control and development. Mr. H. Evans succeeds him as laboratory superintendent. Mr. R. E. Ansell, manager of the sales department, has been appointed a director of Henry Wiggin and Co., Ltd., Mr. O. Lewis Jones has been appointed general production manager, and Mr. C. E. Winfield becomes works manager at Birmingham. At the Zenith Works, Glasgow, Mr. A. B. Graham will relinquish his position as general manager on July 1st in order to undertake special duties concerned with production. Mr. R. J. P. McDonald is to succeed him as works manager.

British Patent Specifications

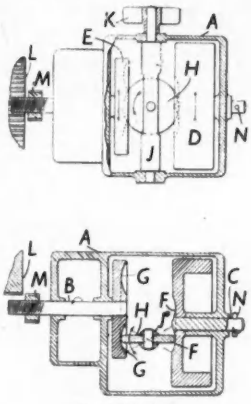
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of the specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 8d. each.

INTERNAL COMBUSTION ENGINES

704,395. June 1, 1951.—AN INERTIA STARTER, Victor Silberstein, 14, Phillimore Court, Kensington, London, W.8.

The inertia starter shown in the drawing comprises a casing *A*, attached to the main body of an internal combustion engine in which are journalled shafts *B* and *C*. Shaft *C* is attached to a flywheel *D* and shaft *B* is attached to a disc *E*. In each of *D* and *E* is cut a toroidal groove *F* and *G* respectively. Groove *F* is formed so that its inner edge on the face of flywheel *D* is closely adjacent to the flywheel axis, which is parallel to, but spaced from, that of disc *E* to such an extent that, in one region, grooves *F* and *G* are exactly opposite one another. A variable gear means provided comprises a roller *H* mounted in a slot in a shaft *J* journalled in casing *A* and provided at one end with a means *K*, shown as a knob, for rotating shaft *J* and tilting roller *H*. This is so fixed and the



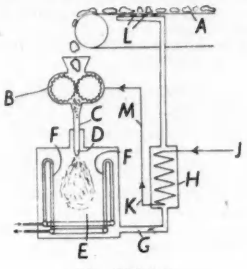
No. 704,395

toroidal grooves are so shaped that, by tilting progressively through 180 deg., the roller can be engaged with the opposed grooves and moved across their faces while maintaining friction-tight contact with them. This results in a change in the distance of the point of contact of roller *H* with each groove from the centre of the respective shafts *B* and *C*, which constitutes a change of operating radius in respect of members *D* and *E* and, hence, an alteration in the gear ratio, from a value substantially exceeding 1 : 1 to a value substantially less than 1 : 1. Finally, the roller becomes disengaged from the grooves, a further tilting movement through 180 deg. in the same sense repeating this cycle of operations. As can be seen from the lower drawing, rotation in a clockwise direction of shaft *J* will effect these operations to give the required reduction of the gear ratio. Thus, continued rotation of means *K* will, in sequence, clutch flywheel *D* and disc *E* together, progressively change the gear ratio and finally disengage the flywheel and disc from one another. A fragment of a gear wheel *L* attached to the engine crankshaft is also shown, and, to effect engagement of shaft *B* with the crankshaft when shaft *H* is rotated, shaft *B* is threaded at its end and carries a conventional loose pinion *M* which is thrown into engagement with teeth on gear wheel *L* when shaft *B* is suddenly rotated. To rotate flywheel *D* a driving force may be applied manually by way of a dog clutch *N*, which may be substituted by a connection to an electric starter.—*February* 24, 1954.

GAS TURBINES

704,662. April 20, 1949.—PREPARATION AND COMBUSTION OF PEAT, John Brown and Co., Ltd., Clydebank Engineering and Shipbuilding Works, Clydebank, Dunbartonshire, Scotland, and John Bennet Bucher, of "Talgarth," Kirkton Hill, Dumbarton, Dunbartonshire, Scotland.

The invention relates to a system of preparation and combustion of peat and similar fuels having a high moisture content in closed cycle gas turbine plants and in steam boilers. Referring to the drawing, it will be seen that the peat is conveyed by an endless belt or rack *A* from stacking sheds or directly from the bog to a mill *B* or similar device, where it is ground before entering a pipe *C* through which it passes to a nozzle *D* to be injected into the combustion chamber *E* of a closed cycle air heater or boiler, or the ground peat may be discharged direct on to a moving grate or into the spreader stoker of a suitably designed combustion chamber. The peat is burned in the combustion chamber *E* and the exhaust gases from the air heater or boiler are collected after they have been used to heat the air, steam or water in tubes *F* and are all or in part led through a pipe *G* and through a heat exchanger *H* in which they give



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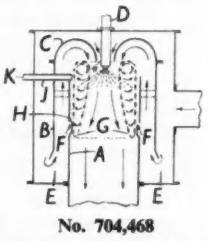
up part of their heat to the combustion air which passes through the heat exchanger via the inlet *J* and the outlet *K*. Having passed through the heat exchanger the exhaust gases are led to a set of nozzles *L* placed adjacent to the upper flight of the endless belt. Combustion air is led by a conduit *M* to the mill *B*, where heat contained in the air is used to dry the peat while it is being ground in the mill and during its passage between the mill and the combustion chamber. Heated combustion air might also be led to the pipe *C* between the mill *B* and the combustion chamber *E*. The endless belt *A* may be contained inside a duct carrying the exhaust gases from the air heater or boiler.—*February* 24, 1954.

704,468. March 22, 1951.—COMBUSTION CHAMBERS FOR LIQUID, GASEOUS OR PULVERISED SOLID FUELS, Gasturbine Maatschappij N.V., 4, Surinamestraat, The Hague, Netherlands. (*Inventor: Hendrik Wouter van Tilen.*)

The drawing shows a combustion chamber for the burning of liquid fuel, with a central fuel nozzle. The chamber comprises a combustion flame tube *A*. Around the flame tube a second concentric casing *B* constituting an air supply channel is arranged, closed at the top by a cover *C* of semi-circular profile, and in the centre of which the fuel atomiser *D* is arranged. The combustion air is supplied from the space *E* and flows at high velocity through the ring-shaped space *F*. The air has its direction of flow turned round through 180 deg. by the shape of the cover *C*, so as to flow axially through the flame tube, the tangents at the end of the gutter profile near the centre of the annular gutter being parallel or constituting a cone with a small apex angle so as to form a region in which the air entering the flame tube will be subject to a whirl of toroidal character, the whirl being extended from the entrance end of the flame tube in the axial direction. As a result of the change of direction caused by the cover *C*, a long-drawn-out whirling region is established in the gases flowing through the flame tube, indicated by the dotted lines *G*. The intensity of the whirl *G* may further be increased by providing the flame tube *A* with an air intake port *H* directed towards the cover, the air film flowing from this port, along the inner surface of the flame tube, having at the same time a further cooling effect on the material of the flame tube. More than one air intake port may be provided. Finally, with the gas whirl *G*, produced according to the invention, the fuel may be ignited from without, for there is a considerable reduction of pressure. It is possible to arrange through the annular space *F* a tube *J*, extending from a place *K* outside the combustion to a point in the whirling area *G*. Through this tube a burning torch or a burning ignition gas or an electrical ignition apparatus may then be introduced so as to ignite the oil mist in the whirl, the ignition then being transmitted to the flame in the centre of the flame tube. Alternative designs for gaseous fuel and mixed fuels are also shown in the specification.—*February* 24, 1954.



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METALLURGY

704,224. March 17, 1952.—INDURATED PELLETS OF FINELY DIVIDED ORE MATERIAL, Erie Mining Company, Hibbing, Minnesota, U.S.A. (*Inventor: Fred Daniel Devaney.*)

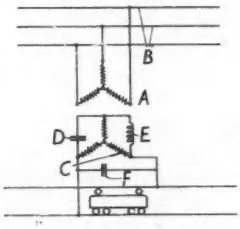
The invention has a particular application for the production of indurated pellets from finely divided oxidic iron ore material, such as "concentrates."

The process is carried out by forming a plastic mixture of the ore material and water, and subjecting the plastic mixture in the form of small masses to prolonged rolling action in an inclined rotary drum for the formation of such masses into pellets. The pellets so formed are then subjected to an indurating temperature for drying and hardening them, which is characterised in that starch is added to the plastic mixture in a small proportion not exceeding 10 lb per ton dry weight for the purpose of hardening them internally and externally, giving compressive strengths up to 7·67 lb per pellet.—*February* 17, 1954.

ELECTRICAL ENGINEERING

702,892. September 18th, 1952.—AN ELECTRIC RAILWAY SYSTEM, Allmanna Svenska Elektriska Aktiebolaget, Vasteras, Sweden.

As the drawing indicates, an overhead line is fed directly from a distribution network or from three-phase transformers connected to the network. *A* is a three-phase transformer connected to a network *B*, the secondary winding *C* being connected to the overhead line and the rails. *D* is a condenser connected to the secondary winding and *E* a reactance



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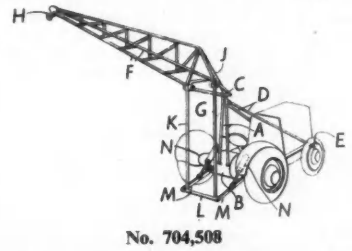
coil connected to it to give a more or less complete balancing of the asymmetry of the load caused by the locomotive. *F* is a condenser for compensating the power factor. Instead of using a three-phase transformer, the transformer feeding the overhead line may be provided with a two-phase secondary winding, and in this case the load of the railway and the power factor compensating condenser are connected to the main voltage of the two-phase secondary system, the balancing condenser is connected in parallel to one of the phase windings and the balancing reactance coil is connected in parallel to the other phase winding.—*January* 27, 1954.

CRANES AND LIFTING APPLIANCES

704,508. May 14, 1952.—AN IMPROVED CRANE, Robert George Rutherford, "Ingledoon," Cheeseman's Creek, New South Wales, Australia.

The invention has been devised to provide a crane for attachment to a tractor and has a jib adapted to be part rotated in a vertical plane by the hydraulic gear of the tractor. A feature of the invention is the comparatively long reach or high lift which can be obtained. The crane consists of a post *A* made of



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two members spaced apart at the bottom, where they are anchored in sockets on the rear frame of the tractor as at *B*. The members are set together at the top where they are joined into a head piece *C*. Stays *D* connected to the post near the top are connected to the front engine mounting by pins *E*. The jib consists of two main members *F* which at the rear end are joined into a bearing member for rotation on the head piece *C* of the post. From this point the members *F* are set outwardly obliquely to a position where they each have a fulcrum bracket *G* and from these brackets they are set inwardly and the ends are connected into a jib head *H*. The fulcrum brackets are joined by a brace *J*. Two fulcrum posts *K* are joined at the bottom by base member *L* mounted in bearings in arms *M* on the tractor. At the top the fulcrum posts are mounted in the fulcrum brackets *G*. The arms *M* are rotated to a limited extent by operation of the tractor hydraulic gear, which is indicated at *N*. This action raises or lowers the fulcrum posts *K* and the jib head *H*. It will be seen that the crane is easily removed from the tractor by removing the pins *E*, disconnecting the base member *L* from the arms *M* and lifting the post members *A* out of the sockets. In a modification the jib is constructed as a ladder type girder.—*February* 24, 1954.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

STRAIGHT-SIDED SPLINES AND SERRATIONS

No. 2059 : 1953. Price 12s. 6d. This specification presents the dimensions of straight-sided, bottom-fitting, shallow and deep splines, together with those for straight-sided 90 deg. coarse serrations. In both cases the figures in the tables allow a choice of three grades of fit and are followed by provisions for full form go gauges and not-go gauges for the individual features. For the greater convenience of the user, the standard is divided into two parts, the first dealing with splines and the second with serrations, each part being completed by several fully illustrated appendices.

This standard is intended to supersede the four previous specifications for splines and serrations which related to general engineering, the automobile and the aircraft industries.

The preparation has now been undertaken of a companion standard for involute splines which will be related to those often referred to as the S.A.E. involute splines. This standard will not include serrations as it is considered that those in this present specification amply provide for the requirements of industry.

RESISTANCE OF CONDUCTIVE AND ANTI-STATIC RUBBER PRODUCTS

No. 2050 : 1953. Price 2s. 6d. This document is complementary to B.S. 2044, "Laboratory Tests for Conductive and Anti-Static Rubbers" and gives resistivity limits for anti-static tyres for vehicles and for anti-static products for use in hospitals, together with methods of testing the actual products.

DIMENSIONS OF DIAMOND ABRASIVE WHEELS AND TOOLS

No. 2064 : 1953. Price 4s. This standard specifies dimensions and tolerances of the following tools in resinoid, vitrified and metallic bonds :—Peripheral wheels, straight cup wheels, double cup wheels, taper cup wheels, bull-nosed cup wheels, dish wheels, cut-off wheels, chip-breaker wheels, milling tools, hollow drills, stone saws and hones.

THERMOSETTING SYNTHETIC RESIN BONDED PAPER INSULATING SHEETS FOR R.F. USE

No. 2076 : 1954. Price 2s. 6d. This publication is a further standard in the series dealing with synthetic resin bonded paper materials for use as electrical insulation. It specifies the requirements for two kinds of natural-coloured thermosetting synthetic resin bonded paper sheets between $^{1}/_{64}$in and $\frac{1}{4}$in thick inclusive, intended for use at radio frequencies up to and including 30 Mc/s. In this respect it is complementary to B.S. 1314 : 1946, B.S. 1885 : 1952, and B.S. 1951 : 1953. The electrical and physical properties specified include power factor and permittivity, insulation resistance, electric strength along laminæ, water absorption, shear strength, as well as those relating to machining and punching (for piercing and blanking). Methods of test to check compliance with the specification are fully described in appendices which include appropriate drawings.

METHOD FOR TESTING OIL-FIRED ROTARY DRYERS FOR USE IN ASPHALT AND COATED MACADAM PLANT

No. 2096 : 1954. Price 2s. 6d.—This is one of a series of standards for plant and equipment used in the road engineering industry. Plant manufacturers, plant users and the Road Research Laboratory (Department of Scientific and Industrial Research) have co-operated in the production of this standard, which provides a method of testing oil-fired rotary dryers, both continuous and batch, under conditions agreed between the parties concerned.

The standard includes recommended test conditions and standard methods for reporting the results of the tests which can serve as a basis on which manufacturers can declare the rate of output of their dryers.

Catalogues

PRECISION COMPONENTS (BARNET), Ltd.—Leaflet describing Kabi terminal blocks.

FAWCETT, PRESTON AND CO., Ltd., Bromborough, Cheshire.—Catalogue of Fawcett machinery.

HARVEY FROST AND CO., Ltd., Bishop's Stortford.—1954 catalogue of transport service equipment.

ALLEY AND MACLELLAN, Ltd., Valve Works, Worcester.—Catalogue "W.12," "Alley" valves for oil.

STEWARTS AND LLOYDS, Ltd., 41, Oswald Street, Glasgow, C.1.—Catalogue for users of pipes for the conveyance of water, gas, sewage, or air, giving all particulars with regard to "S. and L." steel pipes.

WESTINGHOUSE BRAKE AND SIGNAL COMPANY, Ltd., 82, York Way, King's Cross, London, N.1.—Further sections of the Westinghouse signalling catalogue : Part 3, Section 6A, "Interlocked Circuit Controller" ; Part 8, Sections 3, 3A and 3B, "A.C. Relays" ; Part 8, Sections 5D, 5J and 5M, "Plug-In Relays" ; Part 11, Section 4, "Electrically Operated Barrier Style A."

Launches and Trial Trips

DAVID POLLOCK, raised quarter deck self-trimming collier ; built by Hall Russell and Co., Ltd., for the North Thames Gas Board ; length between perpendiculars 320ft, breadth moulded 46ft, depth moulded 22ft 4in/27ft 10in, deadweight 4600 tons on 20ft draught ; four holds ; direct-acting, triple-expansion "North-Eastern Reheat" steam engine, 1275 i.h.p., steam supplied at 220 lb per square inch by two oil-fired cylindrical boilers. Launch, March 9th.

VIERZON, cargo ship ; built by the Chantier de Normandie (Penhoët) for Cie d'Orbigny ; length between perpendiculars 413ft 6in, breadth moulded 56ft 1¼in, depth 34ft, load draught 23ft, deadweight 7700 tons, service speed 13·5 knots ; six holds, derrick complement includes one to lift 15 tons ; two continuous decks, seven watertight bulkheads ; one 150kW turbine-driven generator, three 100kW diesel-driven generators ; one set of geared turbines, 3500 h.p., takes steam at 525 lb per square inch and 750 deg. Fah. from two Penhoët boilers. Trial, March.

Contracts

THE U.D. ENGINEERING COMPANY, Ltd., a subsidiary of United Dairies, Ltd., announces that its representative, Mr. C. D. Wakefield, has signed draft contracts with the U.S.S.R. authorities for the supply of milk bottling machinery to the value of approximately £1,000,000. The contracts cover bottle washing, bottle filling and aluminium capping machines, and also de-crating and crating equipment.

THE GENERAL ELECTRIC COMPANY, Ltd., has received an order for a 2500kW back-pressure geared turbo-alternator set for the Margam Works of the Steel Company of Wales, Ltd. The turbine is to operate under steam conditions of 600 lb pressure, 800 deg. Fah. total temperature, with a back pressure of 165 lb. The alternator will generate at 11kV, three phase, 50 cycles. Messrs. McLellan and Partners are the consultants for the Steel Company of Wales, Ltd.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases, the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

BRITISH INSTITUTION OF RADIO ENGINEERS

Wed., April 7th.—S. WALES SECTION : Glamorgan Technical College, Treforest, "The Manufacture of Radio Receiving Valves," G. P. Thwaites, 6.30 p.m.

CLEVELAND INSTITUTION OF ENGINEERS

Mon., April 5th.—Cleveland Scientific and Technical Institution, Corporation Road, Middlesbrough, "Acid Burdening Blast-Furnace Performance," A. Stirling, 6.30 p.m.

INCORPORATED PLANT ENGINEERS

Mon., April 5th.—DUNDEE BRANCH: Mathers Hotel, Dundee, "Industrial Uses of Magnetic Power," T. G. Hawker, 7.30 p.m.
Tues., April 6th.—EDINBURGH BRANCH : 25, Charlotte Square, Edinburgh, Film, 7 p.m.——LONDON BRANCH : Royal Society of Arts, John Adam Street, Adelphi, W.C.2, "Fans and Fan Engineering Equipment," C. J. Atkins, 7 p.m.
Wed., April 7th.—SOUTHAMPTON BRANCH : Polygon Hotel, Southampton, "Feed Water Treatment," 7.30 p.m.
Thurs., April 8th.—N.E. BRANCH : Roadway House, Oxford Street, Newcastle upon Tyne, "Tobacco Processing," E. W. Watson, 7 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Mon., April 5th.—SHEFFIELD BRANCH : College of Commerce and Technology, Department of Engineering, Pond Street, Sheffield, 1, "The Use of Feeding Materials," D. H. Snelson, 7.30 p.m.
Wed., April 7th.—LANCASHIRE BRANCH : Engineers' Club, Albert Square, Manchester, "Mechanical Aids in the Foundry," J. Blakiston, 7 p.m.——W. RIDING OF YORKSHIRE BRANCH : Technical College, Bradford, Prize Winning Paper in the S. W. Wise Memorial Competition, 7.30 p.m.
Thurs., April 8th.—BEDFORDSHIRE AND HERTFORDSHIRE SECTION : Conservative Club, Luton, "Recent Developments in British Foundries with Special Emphasis on Shell Moulding," A. S. Beech, 7.30 p.m.

INSTITUTE OF FUEL

Thurs., April 8th.—Institution of Mechanical Engineers, 1, Birdcage Walk, Westminster, London, S.W.1, Annual Corporate Meeting, 4.30 p.m., Presidential Address, W. Idris Jones, 5.30 p.m.

INSTITUTE OF MARINE ENGINEERS

Mon., April 5th.—MERSEYSIDE AND N.W. SECTION : 24, Dale Street, Liverpool, Symposium, "Some Interesting Ship and Machinery Defects : Their Investigation and Cure," 6.30 p.m.
Thurs., April 8th.—W. MIDLANDS SECTION : Imperial Hotel, Birmingham, "Heat Exchangers," H. E. Upton, 7 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

To-day, April 2nd.—S. WALES GROUP : S. Wales Institute of Engineers, Park Place, Cardiff, Annual General Meeting, 7 p.m.
Sat., April 3rd.—MIDLANDS CENTRE : Crown Inn, Broad Street, Birmingham, Annual General Meeting, 7.30 p.m.
Mon., April 5th.—SCOTTISH CENTRE : Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "Metal Spraying and Building Up Processes," J. Stuart Scott, 7.30 p.m.
Tues., April 6th.—N.W. CENTRE : Victoria Station Hotel, Preston, "Light-Weight Bodies," Colin C. Bailey, 7.30 p.m.
Wed., April 7th.—E. MIDLANDS CENTRE : Mechanics' Institute, Nottingham, "Lighting for Commercial Vehicles and Its Contribution to Road Safety," G. C. Charlesworth, 7.30 p.m.

INSTITUTE OF TRANSPORT

Mon., April 5th.—METROPOLITAN SECTION : 80, Portland Place, London, W.1, "The Port of London Authority," E. S. Birch, 5.30 p.m.

INSTITUTE OF WELDING

Thurs., April 8th.—SLOUGH SECTION : Community Centre, Farnham Road, Slough, Bucks, Annual General Meeting, 7 p.m.——S. LONDON BRANCH : 2, Savoy Hill, London, W.C.2, Annual General Meeting, "Some Aspects of Non-Destructive Testing," J. S. Blair, 6.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., April 6th.—HYDRAULICS MEETING : Great George Street, Westminster, London, S.W.1, "Land Drainage in England and Wales," E. A. G. Johnson, 5.30 p.m.
Thurs., April 8th.—MIDLANDS ASSOCIATION : James Watt Memorial Institute, Great Charles Street, Birmingham, "Rainfall Run-Off and Storage Elan and Claerwen Gathering Grounds," C. A. Risbridger and W. H. Godfrey, 6 p.m.——N.W. ASSOCIATION : Engineers' Club, Albert Square, Manchester, "Six Similar Shaft Sinking Accidents, 1905-1952 : Precautions Necessary with Cast Iron Linings in Compressed Air," I. C. Easton, 6.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon., April 5th.—RADIO SECTION : Savoy Place, London, W.C.2, Discussion on "Technical Problems Involved in Receiving Alternative Television Programmes," 5.30 p.m.——S. MIDLAND CENTRE : James Watt Memorial Institute, Great Charles Street, Birmingham, "The Development and Application of Nuclear Reactors," R. V. Moore, 6 p.m.
Tues., April 6th.—MEASUREMENTS SECTION : Savoy Place, London, W.C.2, "Determination of the Static and Dynamic Elastic Properties of Resilient Materials," R. S. Jackson, A. J. King and C. R. Maguire ; "A Method of Using Microwaves for Measuring Small Displacements and a Torque Meter Using this Principle," R. Guelke ; "Magnetic Measurement of Mechanical Hardness," D. Hadfield, 5.30 p.m.——S.E. SCOTLAND SUB-CENTRE : Carlton Hotel, North Bridge, Edinburgh, "The Co-ordination of Insulation of High-Voltage Electrical Installations," J. S. Cliff, 7 p.m.
Wed., April 7th.—RADIO AND MEASUREMENTS SECTION : Savoy Place, London, W.C.2, "A Versatile Transistor Circuit," E. H. Cooke-Yarborough ; "The Measurement of the Small-Signal Characteristics of Transistors," E. H. Cooke-Yarborough, C. D. Florida and J. H. Stephen ; "A Bridge for Measuring the A.C. Parameters of Type 'A' Transistors," A. R. Boothroyd and L. K. Datta ; "The Transistor as a Regenerative Amplifier with Some Application to Computing Circuits," G. B. B. Chaplin, 5.30 p.m.——S.W. SCOTLAND SUB-CENTRE : Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "Electrostatic Precipitators," Niels Tröon, 7 p.m.
Thurs., April 8th.—LONDON STUDENTS SECTION : R.E.M.E. Training Centre, Hazebrouck Barracks, Arborfield, Berks, "Machines, Animals and Information," B. Z. De Ferranti, 6.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, April 2nd.—GENERAL MEETING, APPLIED MECHANICS GROUP : 1, Birdcage Walk, Westminster, London, S.W.1, "Shrink Fit Investigations on Simple Rings and on Full-Scale Crankshaft Webs," A. S. T. Thompson, A. W. Scott and C. M. Moir, 5.30 p.m.
Wed., April 7th.—INTERNAL COMBUSTION ENGINE GROUP DISCUSSION : 1, Birdcage Walk, Westminster, London, S.W.1, "The Performance of Compression-Ignition Engines Under Abnormal Conditions," 6.45 p.m.
Fri., April 9th.—GENERAL MEETING, INDUSTRIAL ADMINISTRATION AND ENGINEERING PRODUCTION GROUP : 1, Birdcage Walk, Westminster, London, S.W.1, "The Observation and Control of Dust at Pneumatic Chisels," and "The Observation and Control of Dust at Portable Abrasive Wheels," W. B. Lawrie, A. T. Holman and E. B. James, 5.30 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Wed., April 7th.—WOLVERHAMPTON SECTION : Technical College, Wolverhampton, "The Industrial Applications of Radio-Active Materials," Sir John Cockcroft, 7.15 p.m.
Thurs., April 8th.—LONDON SECTION : Royal Empire Society, Northumberland Avenue, London, W.C.2, "Potentialities of Titanium," J. C. Campbell, 7 p.m.
Fri., April 9th.—W. WALES SECTION : Central Library, Alexandra Road, Swansea, "Metallurgy and Its Importance to the Production Engineer," A. R. E. Singer, 7 p.m.

INSTITUTION OF THE RUBBER INDUSTRY

Tues., April 6th.—Midland Hotel, Station Street, Burton-on-Trent, Film Evening and Annual General Meeting, 7.15 p.m.

INSTITUTION OF SANITARY ENGINEERS

Tues., April 6th.—SESSIONAL MEETING : Caxton Hall, Westminster, London, S.W.1, "The Roles of the Doctor and the Engineer in Public Health," R. F. Guymer, 6 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, April 2nd.—INFORMAL MEETING : Townsend House, Greycoat Place, London, S.W.1, "Some Impressions of North America," J. Foster Petree, 7 p.m.
Wed., April 7th.—MIDLAND SECTION : James Watt Memorial Institute, Great Charles Street, Birmingham, "The Development of Steam Power," W. K. V. Gale, 7 p.m.
Fri., April 9th.—INFORMAL MEETING : Townsend House, Greycoat Place, London, S.W.1, "Modern Laundry Machinery," A. J. Simpson, 7 p.m.

LIVERPOOL METALLURGICAL SOCIETY

Thurs., April 8th.—Liverpool Engineering Society, 24, Dale Street, Liverpool, "The Cold Working of Metals," J. G. Wistreich, 7 p.m.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

Mon., April 5th.—Mining Institute, Neville Hall, Newcastle upon Tyne, "The Development of Ore Carriers in Recent Years," W. A. Stewart, 6.15 p.m.

ROYAL INSTITUTION OF CHARTERED SURVEYORS

Mon., April 5th.—12, Great George Street, Westminster, London, S.W.1, "Research and the Chartered Surveyor," C. A. Hart, 5.30 p.m.

SOCIETY OF ENGINEERS

Mon., April 5th.—ORDINARY MEETING : Geological Society, Burlington House, Piccadilly, London, W.1, "Brittle Fracture in Steel Structures with special reference to 'Liberty' Ships," A. A. Wells, 5 p.m.

SOCIETY OF INSTRUMENT TECHNOLOGY

Thurs., April 8th.—CONTROL SECTION : Manson House, Portland Place, London, W.1, Discussion on "Rationalisation of Units for Electrically Operated Servos," 6.30 p.m.